

mechanically trip free during the levering procedure. A contact shall ground the breaker between and at the operating and test positions.

1. The stationary primary contacts shall be silver-plated and recessed within insulating tubes. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the cell. Provide rails to allow withdrawal of each circuit breaker for inspection and maintenance without the use of a separate lifting device.

D. **Circuit Breaker:** The circuit breakers shall be horizontal drawout type, capable of being withdrawn on rails. The breakers shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts shall be silver-plated copper.

1. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit which can be removed easily. The vacuum interrupter pole unit shall be mounted on [glass polyester supports for 15kV class] [cycloaliphatic epoxy supports for 27kV class]. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate available contact life, shall be easily visible when the breaker is removed from its compartment. The current transfer from the vacuum interrupter moving stem to the breaker main conductor shall be a non-sliding design. The breaker front panel shall be removable when the breaker is withdrawn for ease of inspection and maintenance.
2. The secondary contacts shall be silver-plated and shall automatically engage in the breaker operating position, which can be manually engaged in the breaker test position.
3. Interlocks shall be provided to prevent closing of a breaker between operating and test positions, to trip breakers upon insertion or removal from housing and to discharge stored energy mechanisms upon insertion or removal from the housing. The breaker shall be secured positively in the housing between and including the operating and test positions.
4. Each circuit breaker shall have the following ratings:

Maximum Voltage	kV
BIL Rated	kV
Continuous Current	Amperes [1200] [2000] [3000]
Short Circuit Current	kA
At Rated Maximum	kV
Closing and Latching Capability	kA
Three Second Rating	kA
Nominal 3 Phase MVA Class	MVA
Rated Interrupting Time	Five cycles

Note to Spec Writer: Fill in above data from Table 1.1.

Table 1.1

Rated Max. Voltage	BIL	Rated Short Circuit	3 Sec. Short-Time Current Carrying Capability	Closing and Latching Capability	Nominal 3-Phase MVA Class
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		Current (at rated Max. kV)	K Times Rated Short-Circuit Current	(Momentary) 1.6 K Times Rated Short- Circuit Current	
kV RMS		kA RMS	kA RMS	kA RMS	MVA Class
4.76	60	29	36	58	250
4.76	60	41	49	78	350
8.25	95	33	41		500
	95	18	23	37	500
15	95	28	36	58	750
15	95	37	48	77	1000
15	125	28	36	58	750
15	125	37	48	77	1000
				77	

E. Instrument Transformers: Ring type current transformers shall be furnished as indicated on the contract drawings. The thermal and mechanical ratings of the current transformers shall be coordinated with the circuit breakers. Their accuracy rating shall be equip or higher than ANSI standard requirements. The standard location for the current transformers on the bus side and line side of the breaker units shall be front accessible to permit adding or changing current transformers without removing high voltage insulation connections. Shorting terminal blocks shall be furnished on the secondary of all the current transformers.

1. Voltage and control power transformers of the quantity and ratings indicated in the detail specification shall be supplied. Voltage transformers shall be mounted in drawout drawers contained in an enclosed auxiliary compartment. Control power transformers up to 15kV, 15kVA, single phase shall be mounted in drawout drawers. Control power transformers above 15kV shall be fixed mounted with primary fuses in drawout drawers. Rails shall be provided for each drawer to permit easy inspection, testing and fuse replacement. Shutters shall isolate primary bus stabs when drawers are withdrawn.
2. A mechanical interlock shall be provided to require the secondary breaker to be open before the CPT drawer or CPT primary fuse drawer can be withdrawn.

F. Relays: The switchgear manufacturer shall furnish and install, in the metal-clad switchgear, the quantity, type and rating of protection relays as indicated on the drawings and described hereafter in this specification.

The relays shall be set in the field by:

the Contractor in accordance with settings designated by the Engineer.

- OR -

the Contractor in accordance with settings designated in a coordination study of the system as required elsewhere in the Contract Documents.

- OR -

a qualified representative of the manufacturer, retained by the Contractor, in accordance with settings designated in a coordinated study of the system as required elsewhere in the Contract Documents.

- G. Wire and Cable Terminations: The switchgear manufacturer shall provide suitable terminal blocks for secondary wire terminations and a minimum of 10% spare terminal connections shall be provided. One control circuit cutout device shall be provided in each circuit breaker housing. Switchgear secondary wire shall be #14 AWG, type SIS rated 600 volt, 90 degrees C, furnished with wire markers at each termination. Wires shall terminate on terminal blocks with marker strips numbered in agreement with detailed connection diagrams.
 - 1. Incoming line and feeder cable lugs of the type and size indicated elsewhere shall be furnished.
- H. Construction Type: The switchgear described in these specifications shall be indoor construction, with devices arranged as shown on contract drawings.
 - 1. Each vertical section of outdoor switchgear shall be provided with space heaters. Tubular type heaters operated at half voltage for long life shall be supplied. 500 volt or 250 volt rated heaters shall be used at 240 volts or 120 volts, respectively. Power for space heaters shall be supplied from the switchgear control power transformer.
 - 2. Heaters shall be wired to provide temporary heating during storage.
- I. Finish: The finish shall consist of a coat of ANSI-61, cathodic epoxy paint applied by electro-deposition process to pre-cleaned and phosphatized steel for internal and external parts. The coating shall have corrosion resistance of 300 hours to 5% salt spray. Prior to shipment, the complete assemblies, indoor as well as outdoor, shall be given 1.5 to 2.0 mil thick exterior finish spray coat of air drying high-gloss grey enamel.
- J. Accessories: The switchgear manufacturer shall furnish accessories for test, inspection, maintenance and operation, including:
 - 1. Maintenance tool for manually charging the breaker closing spring and manually opening the shutter
 - 2. Levering crank for moving the breaker between test and connected positions
 - 3. Test jumper for electrically operating the breaker while out of its compartment
 - 4. Breaker lifting yoke used for attachment to breaker for lifting breaker on or off compartment rails
 - 5. Set of rail extensions and rail clamps
 - 6. "Dockable" transport dolly for moving breaker about outside its compartment
 - 7. Test cabinet for testing electrically operated breakers outside housing
 - 8. Portable lifting device for lifting the breaker on or off the rails
 - 9. Ramp for rolling breaker mounted in lower compartment directly onto the floor
 - 10. Electrical levering device

- K. Breaker Operation: The breakers shall be electrically operated by 120 volt AC CLOSE and AC capacitor TRIP.
- L. Control Voltage Source: The control voltage shall be derived from a control power transformer mounted in the switchgear.

2.03 MICROPROCESSOR BASED THREE PHASE RELAY

- A. Provide a Westinghouse type MMCO microprocessor based multiphase instantaneous and time overcurrent relay which provides independent phase and ground trip settings and curve selection. It shall be possible to select any traditional CO-type curve family from the relay's memory.
- B. The relay shall be capable of being programmed and interrogated manually or via an optional IMPACC communications system. All trip parameters (time curve, time dial, pickup, instantaneous) shall be programmable and fault data and metering current values shall be accessible by pushbutton selection from a scrolling digital display. Fault records for the last 16 faults shall be stored internally for troubleshooting and system analysis capability. The most recent 4 records shall be manually available while all 16 shall be accessible via the communications port. The data shall be stored in non-volatile memory with no battery backup required.
- C. Front panel indications shall be as follows:
 - 1. Input current above pickup
 - 2. Time overcurrent trip
 - 3. Instantaneous trip
 - 4. DC power and self check status
 - 5. Each phase and ground current
 - 6. Phase and ground currents for last four faults
- D. Provide addressable communications card capable of transmitting above data over a two wire area network to a central computer for storage and/or printout.
- E. Provide real time clock for time-tagging fault data and for reading present time.

2.04 MISCELLANEOUS

- A. Auxiliary Section: The metal-clad switchgear section for control and instrumentation shall include the following:
 - [2 - Line-to-line] [3 - Line-to-ground] voltage transformers
 - 3 Current transformers
 - 1 Control power transformer

Additional requirements as shown on the Drawings.

- B. Circuit Breaker Sections: The metal-clad switchgear section for control of a main circuit breaker shall include the following:
 - 1. Drawout power circuit breaker rated _____ amperes

2. Set of cable lugs
3. Current transformers, single secondary
4. Circuit breaker control switch with red and green indicating lights
5. Microprocessor based metering system
6. Microprocessor based three phase and ground overcurrent relay, ANSI device number 51/50/N

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation of equipment shall be such that sufficient access and working space is provided for ready and safe operation and maintenance.
- B. Install equipment on concrete pad, as indicated on drawings. Coordinate exact pad dimensions with equipment furnished. Tops of concrete pads shall be level and shall project 4 inches above finished grade and sloped to drain. Conduits for primary, secondary, and grounding conductors shall be set in place prior to pouring of concrete pads.
- C. Switchgear shall be mounted on concrete pads. Units shall be carefully installed so as not to scratch finishes. After installation, finished surfaces shall be inspected and scratches touched up with a finish furnished by the manufacturer especially for this purpose.

3.02 FIELD INSPECTION AND TESTS

- A. Provide the services of an authorized representative of the switchgear equipment manufacturer to make site visits to supervise the field testing and installation to be performed by the Contractor. The manufacturer's representative shall state in writing that the equipment has been correctly installed and tested.
- B. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- C. Perform any other tests recommended by the equipment manufacturer and other tests as described in this specification.
- D. The manufacturer's representative shall supply results of all factory and field tests in writing for submittal to the Owner.

End of Section

SECTION 16347

MEDIUM VOLTAGE-SOLID STATE REDUCED VOLTAGE MOTOR CONTROLLER

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish and install, ready to use, medium voltage, solid state reduced voltage motor controllers for use as indicated on the Drawings and specified herein.
- B. The motor starter shall be furnished and installed complete by the Contractor.
- C. The Contractor shall be responsible for coordinating the motor starter requirements for controlling the pump.

1.02 SUBMITTALS

- A. The medium voltage motor controller shall meet the requirements of the latest edition of Standards for Industrial Control No. ICS published by the National Electrical Manufacturers Association. The following minimum information and drawings shall be submitted for review and acceptance by the Engineer:
 - 1. Plan, front, side views and overall dimension of each medium voltage motor controller.
 - 2. Weight.
 - 3. Internal wiring diagram.
 - 4. External connection diagram showing the wiring to the external controls and devices associated with the medium voltage motor controller.
 - 5. A one-line and a schematic diagram for each medium voltage motor controller.
 - 6. Bill of material list and Manufacturer's Product Data.
 - 7. Installation instructions.
- B. Product information shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents.
- C. The Medium Voltage Solid State Motor Controller shall be constructed, wired and tested in accordance with the latest issue of the following:
 - 1. ANSI American National Standards Institute
 - 2. CSA Canadian Standards Association
 - 3. EEMAC Electrical & Electronic Manufacturers Association of Canada
 - 4. IEEE Institute of Electrical and Electronic Engineers
 - 5. NEC National Electrical Code
 - 6. NEMA National Electrical Manufacturers Association
 - 7. OSHA Occupational Safety & Health Act
 - 8. UL Underwriters Laboratories

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Allen-Bradley MV SMC Plus™, or equal.

2.02 ENVIRONMENTAL CONDITIONS

- A. The controller shall accept nominal plant power of 2400 Volts AC, (+/- 10%), 3 phase, 60 Hz (+/- 3%).
- B. The controller shall be able to operate in an ambient condition of a temperature range of 32° F (0° C) to 104° F (40° C) with a relative humidity of up to 95% (non-condensing).
- C. The equipment shall be capable of being stored in an environment with an ambient temperature range of -40° F (-40° C) to 158° F (+70° C).
- D. The equipment shall be capable of operating at altitudes not exceeding 3300 feet (1000 m) above sea level.

2.03 EQUIPMENT

- A. Refer to the Drawings for location of equipment and components.
- B. Construction
 - 1. Enclosures shall be NEMA Type 3R Outdoor.
 - 2. Enclosure shall have: low-voltage control compartment with separate door; high voltage compartment with separate interlocked door; ac bus compartment with protective barriers; and cable entrance compartment.
 - 3. Arrange load termination's for cable connections as indicated.
 - 4. Incoming power shall enter enclosure from the bottom.
 - 5. Motor cables shall enter enclosure at the bottom. Cables shall be separated from high and low voltage compartments by barriers.
 - 6. Controller shall be in free-standing 1-high individual enclosures.

2.04 CONTROLS

- A. General
 - 1. For overload protection, electronic overload relay with phase unbalance and selectable OL class (10, 20, 30) with hand-reset, shall be included.
 - 2. Control power at 120 volts shall be provided from a control power transformer in each controller. Transformer shall be protected by current-limiting fuses.
 - 3. Controls shall provide instantaneous undervoltage protection when momentary contact push-button is used. Push-button shall be remotely located.
 - 4. Each control shall be protected against single-phasing due to blown fuses and shall have blown fuse indication. Blown fuse indicator shall be mounted on controller door.
 - 5. Controls shall be stationary vacuum.

6. Motor starter type shall be: Reduced Voltage Non-Reversing Autotransformer closed transition (RVNRAT).
7. Refer to motor specification for applicability of starter types to motor types.
8. A MULTILIN Model 239 Motor Protection Relay shall be provided as part of the motor starter. The MULTILIN unit shall be configured to transmit a motor fail alarm, and a motor run status signal to the RTU.

B. Vacuum Break Controls

1. Controller shall be fused type with current-limiting power fuses that provide an interrupting rating to match existing equipment.
2. Starter shall use vacuum contactors.
3. Power bus shall be braced for 80 KA RMS asymmetrical or 50 KA RMS symmetrical.
4. Contactors shall have fixed mounted connections. Coil shall be removable without removing contactor from its mounts. Vacuum interrupter wear checks shall not require removal of contactor.
5. Contactors shall be DC pull in and AC hold.
6. Controller shall be isolated by a non-load-break quick-make quick-break isolation switch operated by an externally mounted handle. Isolation switch shall open control power transformer secondary before opening main circuit. Mechanical interlocks shall be provided to prevent:
 - a. Inadvertent operation of isolation switch under load;
 - b. Opening high voltage compartment door when isolation switch is ON;
 - c. Closing isolation switch with high voltage compartment door open;
 - d. Operating contactor with isolation switch in intermediate position;
 - e. Closing line contactor with door open.
7. Controllers rated 400 amperes up to 7.2 kV and 800 amperes up to 5 kV shall be rated 60 kV Basic Impulse Level (BIL). Control power transformer and autotransformer may be rated 25 kV BIL.

2.05 STATIONARY VACUUM STARTERS

A. Induction Motor Starters

1. Components for Reduced-Voltage Non-Reversing Auto-Transformer Closed Transition (RVNRAT)
 - a. High-Voltage Compartment
 - 1) 1 Set of clip current-limiting fuses and supports
 - 2) 1 Externally operated disconnect switch
 - 3) 1 - 3-pole vacuum contactor
 - 4) 1 Set mechanical interlocks to prevent: opening disconnect when contactor is ON; prevent opening door when disconnect is ON; closing contactor when disconnect is in intermediate position; prevent closing disconnect when high-voltage door is open.
 - 5) 1 Control Power Transformer (CPT)
 - 6) 3 Current Transformers
 - 7) Provisions for motor cable connections

- 8) 1 - 3-pole vacuum contactor as a RUN contactor
- b. Low Voltage Compartment
 - 1) 1 - 3-pole, electronic overload relay with phase unbalance and selectable OL class
 - 2) 1 Normal/Test selector switch
 - 3) 1 Control-circuit fuse
 - 4) 1 CTM (Contactor Timing Module)
 - 5) 1 - Definite time transfer relay
- c. On Door
 - 1) Instruments
 - a) Auxiliary Enclosure (1 High)
 - 2) 1 - 3-pole vacuum contactor-neutral
 - 3) 1 Starting autotransformer with taps for 50, 65 or 80 percent line voltage (set at 65 percent tap)

2.06 INSTRUMENTS

- A. Elapsed-Time Meter
- B. Transducers
- C. Test Blocks

PART 3 - EXECUTION

3.01 GENERAL

- A. The medium voltage motor controllers shall be installed in accordance with the recommendations of the manufacturer.

3.02 TESTS

- A. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- B. The Contractor shall schedule a factory representative for 8 hours of on-site installation inspection, startup, and testing of the equipment specified herein. The factory representative shall submit a field inspection, startup, and test report to certify compliance with their installation requirements.

End of Section

SECTION 16420

SERVICE ENTRANCE SECTION

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the service entrance section and related service equipment.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.
- B. The contractor shall submit shop drawings, catalog cuts, single line diagrams, component layout drawings and equipment elevation. Shop drawings must indicate all ratings, bus bracing, phasing, and utility requirements.
- C. Catalog cuts must be submitted for the service entrance section and components within. Each catalog cut must be properly identified with catalog number and indexed for easy reference.
- D. Single line diagrams must be complete with circuit numbers to match the Drawings. Components must be sized and shown in a bill of materials.
- E. A wiring diagram must be submitted to show connection and control of devices such as ground fault protection, phase protection relays, and other components. Wiring diagram must include component numbers, matching the bill of materials.
- F. Service entrance section must be approved for connection by the serving utility company prior to Engineer's review.
- G. The SES must be UL listed as a complete assembly suitable for Service Entrance Duty.

PART 2 - PRODUCTS

2.01 SERVICE ENTRANCE SECTION (SES)

- A. The SES shall be a single panel, frame or assembly of panels on which shall be mounted on a deadfront mounting plate, circuit breakers or fused switches, metering equipment and any monitoring or protection devices as indicated on the drawings.
- B. The SES shall be a one-piece enclosure with front accessibility unless otherwise required. The SES shall have a metered distribution section complete with meter socket and factory installed test blocks, customer metering, and a pull section, overhead or

underground, as indicated on the drawings; all of which shall comply with the requirements of the serving utility.

- C. The enclosure shall be zinc coated steel, minimum 12 gauge thickness. Cabinet shall be protected against corrosion in accordance with U.L. 50, Cabinets and Boxes, Section 13. Exterior covers to be minimum 14 gauge steel, and shall have padlocking provisions. Deadfront shall be a hinged type, 16 gauge minimum, and shall not require the use of a tool to expose interior components for installation or servicing. Factory installed components shall be U.L. listed. Factory installed conductors shall be copper, size and type to conform to NEC and U.L. requirements (minimum size #14 AWG). Construction shall be such to prevent the entry of rodents into the interior. Ventilation openings shall be provided.
- D. Unless otherwise indicated on the Drawings, the enclosure shall be rated NEMA 3R for outdoor use, or NEMA 1A for indoor use.
- E. Bus bars (including neutral and ground) shall be silver or tin plated solid copper and braced to withstand short circuit amps as indicated on the Drawings.
- F. The SES shall have a steel nameplate stamped indicating the equipment voltage, amperage and short circuit withstand rating, mounted on the outside of the enclosure.
- G. Padlocking provisions shall be provided to lock the device in the "OFF" position.
- H. The overcurrent protection shall be rated as indicated, and as specified elsewhere herein.
- I. Metering and instrumentation shall be as indicated, and as specified elsewhere herein.
- J. On circuit breakers 800 amps and larger, a trip button shall be provided.
- K. The Service Entrance Section shall be as manufactured by Square D, Cutler-Hammer, General Electric, Siemens, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The Service Entrance Section shall be installed per manufacturer's instructions, as indicated on the drawings, per all applicable NEC and local codes and regulations, and shall comply with serving utility's requirements.
- B. Grounding shall be provided as required by the NEC, and as indicated on the Drawings.

3.02 TESTING

- A. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

End of Section

SECTION 16430

CUSTOMER POWER METERING SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This specification covers the customer power monitoring system installed on the service entrance section(s), motor control center(s), and other distribution panel(s) as indicated on Plans.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.
- B. Submit manufacturer's catalog cut sheet indicating all options to be supplied as specified herein.
- C. Submit shop drawing indicating wiring connection diagram and elevation drawing indicating location of component(s) on the service entrance section.

1.03 MANUFACTURERS

- A. Acceptable manufacturers subject to compliance with the specifications herein are as follows:
 - 1. Westinghouse
 - 2. Square D
 - 3. Multilin

PART 2 - PRODUCTS

2.01 GENERAL

- A. The system shall consist of electronic circuit monitors as required to obtain signals as specified herein. Components shall include CT's, PT's, CPT, etc. and other devices as required.
 - 1. The electronic Circuit Monitors shall report metering values such as frequency, temperature, current, voltage, power factor, power, demand current, and real power, and accumulated energy.
 - 2. Each Circuit Monitor shall retain historical circuit data, time and date, setup and configuration values, and diagnostics data in the event of a control power failure without the need for an internal battery.

3. Each Circuit Monitor shall be capable of capturing current and voltage waveforms which may be exported to a personal computer where waveform or other power quality analysis may be performed.
4. The Circuit Monitor shall include an LED readout which will allow local display of the following electrical parameters:
 - a. Current, per phase RMS
 - b. Voltage, phase-to-phase & phase-to-neutral
 - c. Real power, 3-phase total
 - d. Reactive power, 3-phase total
 - e. Apparent power, 3-phase total
 - f. Power factor, 3-phase total & per phase
 - g. Frequency
 - h. Peak demand current, per phase
 - i. Peak demand, real power
 - j. Accumulated Energy, (MWH and MVARH)
5. Reset the following electrical parameters shall also be allowed from the front of the Circuit Monitor:
 - a. Peak demand current
 - b. Peak demand power
 - c. Energy (MWH)
 - d. Reactive energy (MVARH)
6. Circuit Monitor setup for system requirements shall be allowed from the front of the Circuit Monitor. Setup provisions shall include:
 - a. CT rating (xxxx:5)
 - b. PT rating (xxxxx:120)
 - c. System type (3-wire and 4-wire)
 - d. Demand interval (5-60 min.)
7. All reset and functions shall be keyswitch protected to prevent unauthorized/accidental changes.
8. Unit shall be configured to communicate over Modbus RTU protocol using RS-485 cable network connections with a remote PLC.

- B. The system shall have System Display units which display data from the Circuit Monitors. The display unit shall contain the following:
1. Each System Display shall provide real-time access to all metering data available for each circuit (present as well as historical data).
 2. Each System Display unit shall access and display the data available from selected electronic Circuit Monitors connected on the individual data transfer network.
 3. The System Display unit shall utilize a 4 line by 20 character, high contrast LCD technology display with backlighting to provide high reliability and superior readability in all light conditions.
 4. The level of backlighting as well as the contrast shall be adjustable.
 5. The System Display unit shall allow for easy operation by providing a keypad with large keys for operator selections.
 6. The keys shall have a raised perimeter and tactile feedback to ensure a positive response even with gloved hand operation.

7. The keys shall be clearly marked to indicate the function and separated into meaningful groups with display prompting to assist the user in operation.
8. Each System Display unit shall be configured by the manufacturer with all necessary data such as CT ratios, PT ratios, main and feeder device nameplates, demand alarm set points, etc.
9. It shall be possible to change the configuration for each System Display unit using the keypad provided on each display.
10. This capability shall be password protected to prevent unauthorized modification of the configuration.
11. All data with the exception of the captured waveform shall be accessible by the System Display unit.
12. Data shall be displayed in a logically organized manner complete with the proper scaling and units.
13. It shall be possible to sequentially view all available data from a selected Circuit Monitor by single keystroke advancing through the various display pages.
14. It shall be possible to view the same pages of data from other Circuit Monitors by single keystroke advancing back and forth from Circuit Monitor to Circuit Monitor.

C. Software for a personal computer shall be provided as specified herein:

1. The Metering System Software to be supplied shall be suitable for operation on a personal computer.
2. System Software shall be capable of alarm reporting, event logging, data logging, on-line monitoring of instrumentation/status/alarms, waveform analysis, manual control of circuit breakers or other selected devices and shall include sufficient levels of password protection.
3. The software shall be capable of performing background activities such as alarms and automatic logging while the computer is used for other programs such as word processing, spreadsheet, etc.
4. Software shall be supplied by switchgear manufacturer which will display all information available from the Circuit Monitors. This software shall include the following characteristics/capabilities:
 - a. MicroSoft windows based with mouse
 - b. View & log instrumentation data
 - c. View voltage/current waveforms and analyze waveform data
 - d. Perform diagnostics/setup
 - e. Display tables, charts & graphs
 - f. Display meters, meter panels graphically
 - g. Event logging
 - h. Alarm reporting
 - i. Reset energy alarms/historical data
 - j. Background data logging
 - k. Three level password protection
 - l. Manual control of Circuit Monitor outputs
 - m. Display status (circuit breakers, relays, trip units, etc.)

PART 3 - EXECUTION

3.01 INSTALLATION

- A. System Display units shall be installed by the manufacturer in the switchgear as indicated on the plans.
- B. The System Display units shall be flush mounted on switchgear door panels.
- C. Electronic Circuit Monitors shall be installed by the switchgear manufacturer for all circuits as indicated by the project drawings.
- D. All control power, CT, PT, and communications wire shall be factory wired and harnessed within the switchgear lineup.
- E. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements including wire type to be used.
- F. The metering components included within the service entrance sections shall be factory installed, wired and tested prior to shipment to the job site.
- G. All wiring required to externally connect the personal computer shall be installed by the Contractor per manufacturer's requirements and per other portions of these specifications.
- H. Contractor interconnection wiring requirements shall be clearly identified on the metering system drawings to be submitted for approval.

3.02 TESTING

- A. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

3.03 TRAINING

- A. On-site start-up and training of the metering system shall be included in the project bid.
- B. Start-up shall include a complete working demonstration of the system with simulation of possible operating conditions which may be encountered.
- C. Training shall include any documentation and hands-on exercises necessary to enable operations personnel to assume full operating responsibility for the system after completion of the training period.
- D. The project bid shall include 2 days start-up assistance and 1 day training.

End of Section

SECTION 16440

DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers electrical disconnecting switches.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

PART 2 - PRODUCTS

2.01 DISCONNECT SWITCHES

- A. Disconnect switches shall be heavy-duty safety switches with a quick-make, quick-break operating mechanism, with full cover interlock, and indicator handle. The disconnect switches shall be furnished with fuses of the size indicated on the Drawings. One set of spare fuses shall be furnished for each fused disconnect switch. Disconnect switches shall be NEMA type HD heavy duty construction, UL 98 listed.
- B. Enclosures shall be rated NEMA 12 for indoor use, and NEMA 3R for outdoor use, unless otherwise indicated on the Drawings.
- C. Disconnect switch handle shall be padlockable.
- D. Disconnect switches in the corrosive areas as indicated on the Drawings, shall be NEMA 4X, 304 stainless steel.
- E. Disconnect switches shall be as manufactured by Square D, Cutler Hammer, Allen-Bradley, General Electric, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Disconnect switches shall be installed as indicated on the Drawings.
- B. Provide grounding per NEC, and Section 16170.

3.02 TESTING

- A. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

End of Section

SECTION 16470

PANELBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Panelboards furnished in accordance with the Plans and this specification.
 - 1. Service entrance rated main distribution panelboards.
 - 2. Distribution panelboards.
 - 3. Lighting and appliance branch circuit panelboards.
 - 4. Electronic Power Metering on panelboards per Section 2.05, when specified.

1.02 RELATED SECTIONS

- A. Section 16000 – General Electrical Requirements
- B. Section 16195 - Electrical Identification
- C. Section 16505 – Transient Voltage Surge Suppression

1.03 CODES, STANDARDS, AND REGULATORY REQUIREMENTS

- A. All parts, materials, assembly, installation, testing and commissioning shall meet the requirements of the latest edition of the following Codes and Standards, and Regulatory agencies. In case of the conflict between the codes' requirement, the most stringent shall apply.
 - 1. Underwriters' Laboratories:
 - a. Panelboards: UL 67
 - b. Enclosures for Electrical Equipment: UL 50
 - c. Molded Case Circuit breakers and Circuit Breaker Enclosures: UL489
 - 2. FS W-C-375 - Circuit Breakers, Molded Case, Branch Circuit and Service.
 - 3. FS W-P-115 - Power Distribution Panel.
 - 4. NEMA AB 1 - Molded Case Circuit Breakers.
 - 5. NEMA PB 1 - Panelboards.
 - 6. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
 - 7. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment.
 - 8. NFPA 70 - National Electrical Code.
 - 9. UBC - Uniform Building Code.
 - 10. NETA - International Electrical Testing Association.

1.04 SUBMITTALS

- A. Shop drawings for equipment and component devices.

- B. Include outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker arrangement, sizes and numbering system.
- C. Include information on all the accessories, locking hardware, shunt trip, under-voltage release mechanism, typical thermal magnetic curves for each size and type.

1.05 SPARE PARTS

- A. Keys: Furnish two door keys for each panelboard.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. General Electric
- B. Siemens – ITE
- C. Square D
- D. Cutler-Hammer
- E. Approved Equal

2.02 BUS AND HARDWARE

- A. Panelboards shall be completely factory assembled and equipped with the type, size and number of branch circuit breakers, arranged and numbered as shown on the Plans. Panelboards shall be fully rated. Series rated panelboards are not acceptable.
- B. All multi-pole breakers shall be common trip. Branch circuits shall be arranged using double row construction. Bus sequence shall be ABC top to bottom, left to right for both top and bottom fed panels. Provisions or space for future breakers shall be located at the bottom of the panel and be fully bussed, complete with all necessary mounting hardware. Use at least 100 ampere breaker-connecting bus straps and mounting hardware.
- C. Where SPARE is indicated on the panel schedule(s), the specified circuit breaker and at least 100 ampere branch-circuit busing and mounting hardware shall be installed.
- D. Where SPACE is indicated on the panel schedule(s), 100 ampere branch-circuit busing and mounting hardware shall be installed, ready for future installation of circuit breakers, furnished by others. At least 20% spare pole spaces, grouped in multiples of three, shall be provided in each panelboard, for future installation by the Owner. Provide single pole filler plates in the spaces, as required.
- E. A nameplate shall be provided, and located near the top of the front trim on the exterior surface, listing panel type and ratings, as required by UL. Each circuit shall be

permanently numbered to agree with the panel schedule, using plastic or metal buttons mounted adjacent to the breaker and secured by rivets or grommets with an engraved or depressed number. Adhesive numbering tape, painted numbers, or use of more than one number per breaker is not acceptable.

- F. Main vertical bus bars shall be copper and silver or tin plated per UL requirements. Bus bars shall be supported by glass-filled polyester-type insulators. All bolts, used to connect current-carrying parts together, shall be accessible for tightening from the front of the panel. Bus bars shall be factory drilled and tapped with spacing arranged to permit breaker interchange, from the front, while the panel is energized.
- G. Neutral bus shall be copper and insulated from the cabinet and all other parts. It shall be rigidly mounted in the panel and shall be provided with a solderless cable connector for each circuit breaker and each space in the panelboard and the main connecting lug(s).
- H. A 1/4-inch (8mm) thick copper equipment ground bus, of sufficient width and length, shall be solidly bolted and grounded to the enclosure at the bottom and shall leave clear space for the bottom cable entries. The bus shall be drilled and tapped for 1/4" (8mm) - #20 machine screws in number to agree with branch circuits and spaces. A solderless connector, for No. 2 to No. 4/0 cable size, shall be bolted to the ground bus.
- I. Copper bus bars shall be of sufficient size to provide a current density of not more than 1000 amperes per square inch of cross section, and not more than 200 amperes per square inch at bolted connections.
- J. Minimum Short Circuit Rating for Bus Bracing: The bus shall be braced for the minimum symmetrical short circuit rating of the panel, as shown on the panel schedule.
- K. Provide main bus pressure connectors (main lugs) and separately supported sub-feed pressure connectors (lug landings) where noted. Provide additional bottom raceway space to accommodate pressure connectors and lug landings. In no instance shall the gutter space be less than required by NFPA-70.
- L. Provide Transient Voltage Surge Suppression where required on Plans.
- M. Where required on Plans, provide re-installed locking devices for locking each circuit breaker in the OPEN position, by means of a padlock. Locking devices shall not be removable from the front of the panel with the trim in place. Attachment of the locking device to the panel with adhesives is not acceptable.

2.03 CIRCUIT BREAKERS

- A. Molded Case Circuit Breakers: NEMA AB 1; provide bolt-on type circuit breakers with integral thermal and instantaneous magnetic trip in each pole and common trip handle for all poles. Provide circuit breakers, UL listed as Type HACR, for air conditioning equipment branch circuits. Provide circuit breakers, UL listed as Type SWD, for lighting

circuits. Provide UL Class A ground fault interrupter circuit breakers where shown on Plans.

- B. Instantaneous magnetic trips shall be accessible and adjustable from the front of the breaker on frame sizes above 100 amperes.
- C. All breakers shall be rigidly mounted, separately removable and independent of trim plates for their support. Breakers shall be bolt on type.
- D. The minimum width of one pole shall be 1-3/8 inches. The breaker shall be "E" frame minimum.
- E. The minimum symmetrical interrupting rating for molded-case circuit breakers shall be as specified on the panel schedule(s). Series rated breakers are not acceptable.

2.04 CABINETS (BOXES)

- A. All details of construction and methods of assembly shall meet the requirements of the "Enclosures for Electrical Equipment" of the Underwriters' Laboratories. The panel box shall not be less than 20" wide, 4.5" deep and of sufficient height to enclose the specified main and branch circuit breakers, buses, metering equipment and wire gutter. The panelboard enclosure shall be fabricated from code-gauge galvanized or galvanized-annealed steel without knockouts and with full front flange. The panel front shall be as shown on the plans and fabricated from cold rolled steel. Surface mounted panel boxes shall be finished with an ANSI-61 light grey baked enamel. There shall be no screws projecting into the wiring raceways. The panelboard enclosure type shall be coordinated with the environment and location shown on the plans. Unless noted otherwise on the panel schedule, provide NEMA 3R for panelboards located out of doors and NEMA 12 elsewhere.
- B. The front trim shall have full-length hinged outer door designed to expose the wiring raceways and breakers, when open. Another, inner hinged door shall expose breakers only, when open, making this a door-in-door construction. Both doors shall open to the right.
- C. Both doors shall be provided with concealed butt or piano hinges. A suitable latch, which can be operated without tools, shall be provided to properly hold the inner door closed. For doors 30 inches (765mm) high or less, a flush-type latch is satisfactory. For doors more than 30 inches (765) high, a vault-type handle shall be provided with a three-point latch that holds the door closed at the top and bottom. The outer door shall be secured with at least four (4) captured oval head machine screws.
- D. A sturdy metal frame, with a clear plastic cover, for an 8-1/2 inch x 11 inch panel schedule, shall be attached inside of the panel door with the RTV adhesive.
- E. Panel trim and doors, and surface mounted cabinets shall be thoroughly cleaned, given a rust-inhibiting treatment, and finished with an ANSI-61 light grey baked enamel.

- F. All panelboards shall bear the Underwriters' Laboratories label.

2.05 ELECTRONIC POWER METERING

- A. The panelboard shall be provided with the electronic power metering, where shown on Plans
 - 1. A digital electronic power shall be used. The meter shall measure the real-time RMS values of the phase currents (Ampere), Ampere demand, phase and line voltages (Volts), KW, KW demand, KWHR, KVA, KVA demand, KVAR, KVAR demand, power factor, and frequency.
 - 2. A communications module shall be provided using an industry standard RS-232 or RS-485 serial bus. Modbus RTU shall be the protocol.
 - 3. The electronic power meter shall have non-volatile memory to record at least 100 time-stamped alarms and events.
 - 4. All potential, control power and current transformers shall be completely installed and wired to the power meter in the panelboard.
 - 5. The electronic power meter shall be Multilin PQM, Siemens Model 4700 Power Meter, Power Measurement Ltd. Model 3710 ACM, or approved equal.

2.06 EXCEPTIONS

- A. The bidders shall list all the exceptions taken from the specification with their quote. If no exceptions are listed with the bid, it is understood that the bidder shall meet all the requirements of this specification and applicable Codes and Standards.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install panelboards plumb and flush with wall finishes, in conformance with NEMA PB 1.1. Where surface mounted, provide suitable supports and rack all branch circuit conduits. Where mounted on concrete wall, install with ½" (15mm) steel spacers behind the panel. All mounting attachments and connections shall be designed in conformance with the minimum lateral seismic force of 0.5W per the most current adopted version of the UBC.
- B. Height: Install top of trim 78 inches above finished floor, unless otherwise noted on drawings.
- C. Provide filler plates for unused spaces in panelboards.
- D. Provide typed or neatly hand printed 8-1/2x11-inch circuit directory for each panelboard, in the format as shown on the drawings. Revise directory to reflect circuiting changes required to balance phase loads.

3.02 QUALITY CONTROL

- A. Owner reserves the right to witness any of the following tests conducted by the contractor and shall be notified in advance of these tests. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- B. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Maintain proper phasing for multi-wire branch circuits.

3.03 FINAL SUBMITTALS

- A. After completion of the installation, wiring and testing, submit the following information within two weeks of the equipment acceptance.
 - 1. As-Built Panel Schedules.
 - 2. Copy of the certified test report described in Section 3.02.

END OF SECTION

SECTION 16474

MOTOR CONTROL EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
Separately mounted combination motor starters (including those supplied with equipment), manual motor starters, separately mounted circuit breakers and control equipment.
- B. Related Sections include but are not necessarily limited to:
Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
Division 1 - General Requirements.
Section 16000 - Electrical: Basic Requirements.
Section 16170 - Grounding.

1.02 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. American National Standards Institute (ANSI):
 - a. C62.41, Guide for Surge Voltages in Low Voltage AC Power Circuits.
 - 2. Institute of Electrical and Electronics Engineers (IEEE).
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. ICS 2, Industrial Control Devices, Controllers, and Assemblies.
 - b. 250, Enclosures for Electrical Equipment (1000 Volt Maximum).
 - 4. National Fire Protection Association (NFPA):
 - a. 70, National Electrical Code (NEC).
 - 5. Underwriters Laboratories, Inc (UL):
 - a. 845, Electric Motor Control Centers.
- B. Miscellaneous:
 - 1. Verify motor horsepower loads, other equipment loads, and controls from approved shop drawings and notify Engineer of any discrepancies.
 - 2. Verify the required instrumentation and control wiring for a complete system and notify Engineer of any discrepancies.

1.03 SUBMITTALS

- A. Shop Drawings:
 - 1. See Sections 01340 and 16000.
 - 2. Typical wiring diagrams for all control equipment.
- B. Operation and Maintenance Manuals:
 - 1. See Section 01340.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Combination motor starters:
 - a. General Electric.
 - b. Square D.
 - c. Cutler Hammer.
 - d. Siemens.
 2. Control relays:
 - a. General Electric.
 - b. Square D.
 - c. Cutler Hammer.
 - d. Siemens.
 3. Electronic timers:
 - a. Tork.
 - b. Paragon.
 4. Timing relays:
 - a. Agastat.
 - b. General Electric.
 - c. Square D.
 - d. Cutler Hammer.
 - e. Siemens.
 5. Enclosures:
 - a. Hoffman.
 - b. Hammond.
 - c. Rittal.
 6. Manual motor starters:
 - a. General Electric.
 - b. Square D.
 - c. Cutler Hammer.
 - d. Siemens.
 7. Separately mounted circuit breakers:
 - a. General Electric.
 - b. Siemens.
 - c. Square D.
 - d. Cutler Hammer.
 8. Terminal blocks:
 - a. Entrelec
 - b. Phoenix Contact
 - c. Weidmuller
 - d. or equal
 9. Surge protection blocks (SPB)
 - a. TELEMATIC, series SD

b. or equal.

B. Submit requests for substitution in accordance with Specification Section 01630.

2.02 COMPONENTS

A. Main and Feeder Circuit Breakers in MCC and Separately Mounted:

1. Molded case thermal magnetic or solid state trip type, with minimum interrupting rating equal to the main bus fault current rating:
2. Circuit breaker frame sizes 150 A and less:
 - a. Non-interchangeable, non-adjustable thermal magnetic trip units.
3. Circuit breaker frame sizes 225 A and higher:
 - a. Interchangeable and adjustable thermal magnetic trip units.
4. Circuit breaker frame sizes 600 A and greater:
 - a. Solid state trip units, unless otherwise noted on the Drawings.
 - b. Current sensor or rating plug.
 - c. Adjustable current setting: Minimum range 70 to 100 percent of current sensor or rating plug.
 - d. Adjustable instantaneous pickup: Minimum range 3 to 8 times.
 - e. On circuit breakers 1000 A and larger provide integral ground fault protection.
 - 1) Adjustable pick-up.
 - 2) Adjustable delay.
5. All circuit breakers to be provided with padlocking provision in the OFF position for up to three padlocks.
6. Thermal capability:
 - a. Frame size 800 amp continuous and below:
 - b. Shall be provided for use at 80 percent of their continuous rating unless otherwise indicated on the Drawings.
 - c. Frame size 1000 amp continuous and above:
 - 1) Shall be UL listed for application in their intended enclosure for 100 percent of their continuous rating.
 - 2) Wiring associated with these circuit breakers shall have a dry location maximum operating temperature of 90 DegC.

B. Provide ambient compensated devices.

C. Combination Motor Starters:

1. Circuit breaker shall be motor circuit protector (MCP) type.
2. Contactor shall be NEMA rated.
 - a. One-half size and IEC sized starters not permitted.
3. Operating handle shall clearly indicate whether circuit breaker is ON, OFF, or TRIPPED.
 - a. Provide means to lock each circuit breaker handle in OFF position with cover closed by means of up to three padlocks.
 - b. Interlock so that circuit breaker must be in OFF position before door can be opened. Provide defeater mechanism for use by authorized personnel.

4. Provide starter unit with ambient compensated, external manually resettable, three bimetallic type overload relays. Coordinate size with actual motor full load current.
 - a. For motors with power factor correction capacitors size heater elements to compensate for the capacitors effect on load current.
 5. Provide heavy-duty oiltight selector switches, pushbuttons, push-to-test pilot lights, or other devices as indicated on the Drawings. These devices will be accessible with the door closed.
 6. Provide each starter with two extra field reversible NO auxiliary contacts for future use, and as shown on the Drawings.
 7. Provide each starter with 480/120 V control power transformer fused on primary and secondary side, and rated for 140 percent of required load.
 8. Provide six-digit readout elapsed time meter where indicated on Drawings.
 9. Starter units will have the same fault current withstand rating as the MCC main bus fault current withstand rating from which they are fed.
 10. Provide each starter with the following status signals, wired to terminal boards.
 - a. Motor run contact (N.O.).
 - b. Motor stop contact (N.C.).
 - c. Auxiliary overload relay contact (N.O.).
- D. Selector Switches, Indicating Lights, and Pushbuttons:
1. Heavy-duty oiltight/watertight for unclassified or wet areas.
 2. NEMA 4 for outdoor applications or panels specified WP.
 3. NEMA 4X for corrosive areas.
 4. NEMA 7 and 9 for Class I, Division I Groups C and D; and Class II, Division I, Groups E, F, and G hazardous locations.
 5. Selector switches shall have standard gloved operator.
 6. Pushbuttons shall have standard flush operator.
 7. Provide switch positions and contacts:
 - a. As specified on Contract Drawings or as necessary for proper control.
 8. Switch contacts shall be NEMA A600 rated.
 9. Full voltage indicating lights, unless specified otherwise.
 10. Provide 100 percent replacement lamps for indicating lights.
 11. Provide one replacement lens for each color indicating light.
- E. Control Relays:
1. Provide industrial control relays as specified on the Drawings and as required for proper operation and control of supplied equipment.
 2. All control relays shall have 120 V coils capable of operating on line voltage fluctuations of +/-10 percent unless specified otherwise.
 3. Provide contacts for all required control plus two spares.
- F. Time Delay Relays:
1. Provide time delay relays with delayed pickup or release as specified on Drawings.
 2. All time delay relays shall operate at 115 V AC +/-10 percent.
 3. Heavy duty, solid state construction.
 4. Contact rating: 5A/250V.

5. Provide external adjust dial with 0-30 second range unless specified otherwise.
6. Operating temperature ranges: -18 to +50 DegC.
7. Repeat accuracy: +/-3 percent plus +/-10ms over specified voltage range.
8. Provide all required contacts plus two N.O.spares.
9. Provide auxiliary relays as required to perform functions specified on Drawings.

G. Terminal Blocks:

1. Terminal blocks shall mount on standard DIN rail, and be of the size required for conductors therein. A minimum of 25 percent spares shall be provided in each terminal box. No more than 2 conductors shall be allowed per termination. Jumper bar assemblies shall be installed for interconnecting terminal blocks, distributing power and signal commons. Terminal blocks shall be U.L. rated for 600 Volts, and 20 Amps, minimum.
2. Grounding terminal blocks shall be provided for instrumentation cable shields. The terminal blocks shall have distinctive 2-color bodies, and shall be mounted to the DIN rail with metal screw down type clamps, providing a positive ground connection. One grounding terminal block shall be installed for every 2 instrument cables terminated. Grounding terminal blocks shall be U.L. rated for 600 Volts, and 20 Amps, minimum.
3. Terminal blocks shall be available in a variety of colors, including red, green, blue, gray, black, yellow, and orange.
4. DIN mount fuse holders shall have blown fuse indicators for DC and AC circuits. Fuse holders shall be of the compression clamp type. Fuse holders shall be U.L. listed, and rated for 600 Volts. Fuse sizes shall not exceed the U.L. current rating for the fuse holders.
5. DIN rail shall be prepunched, zinc bichromate plated steel. Symmetrical DIN rail shall be 35mmX7.5mm, minimum.
6. Terminal blocks for 4 to 20 milliamp signals shall have knife disconnect switches, and accessible test points for testing and measurement of current loop signals, without the need for removing wire terminations.

H. Surge Protection Blocks (SPB)

1. Analog inputs and outputs shall be terminated at surge protection blocks (SPB). The SPBs shall be designed for a working voltage of 32 volts, and shall be fused.
2. SPBs shall provide full hybrid line to line protection, and shall have a GDT rating of 10,000 A (8/20 μ s pulse waveform).
3. SPBs shall be UL94 V-2 listed.

I. Enclosures and Control Panels:

1. NEMA 12 for unclassified areas.
2. NEMA 4 for outdoor or wet areas.
3. NEMA 4X for corrosive areas.
4. NEMA 7 for Class I hazardous locations.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install as indicated and in accordance with manufacturer's recommendations and instructions.
- B. Mount other equipment as shown on the Drawings, and per NEC.
- C. Ground all equipment per NEC.

3.02 TESTING

- A. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

End Of Section

SECTION 16475

MINI POWER CENTERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers electrical Mini Power Centers.

PART 2 - PRODUCTS

2.01 MINI POWER CENTERS

- A. The contractor shall furnish and install Mini Power Centers, as indicated on the Electrical Drawings.
- B. Single phase transformers shall be 480 volt primary and 240/120 volt secondary. Three phase transformers shall be 480 volt primary and 208 Y/120 volt secondary.
- C. All transformers shall have a minimum of 2-5% full capacity primary taps below normal and shall be rated 115 degree temperature rise above 40 degree maximum ambient. All insulating materials are to be in accordance with current ANSI C89.2 and NEMA ST20 standards for a 185 degree UL component recognized insulation system. Transformers are to be encapsulated using a sand-epoxy resin mixture to provide maximum protection against moisture, dust and corrosive environments.
- D. Enclosures shall be cleaned, phosphatized and electrostatically powder coated and shall be UL Listed for indoor and outdoor use.
- E. Mini Power Center Units shall include integrally mounted and wired primary and secondary main circuit breakers in accordance with National Electrical Code requirement. These breakers and all branch circuit breakers shall be bolt-on type and as specified elsewhere within these specifications. Minimum A/C rating shall be as indicated on Drawings.
- F. A hinged access door shall be provided which maintains itself in the open position when desired, and which has padlock provisions to prevent unauthorized entry. All live parts are to be fully enclosed for personnel protection when installation is completed. The transformer and panelboards shall be constructed with separate enclosures capable of being assembled or disassembled as independent units.
- G. The Mini Power Centers shall be UL Listed for use as service equipment.
- H. The Mini Power Centers shall be as manufactured by Square D Company or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Mini Power Centers shall be installed as indicated on the drawings and per manufacturer's instruction.

3.02 TESTING

- A. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

End of Section

SECTION 16476

LOW VOLTAGE CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish and install, low voltage circuit breakers, as indicated on the Drawings and specified herein.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

1.03 QUALITY ASSURANCE

- A. The breaker manufacturer's facilities shall be ISO 9001 certified.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Circuit breakers shall be as manufactured by Square D, Cutler-Hammer, Allen-Bradley, General Electric, or equal.
- B. Circuit breaker frame, trip, short circuit, and interruption ratings shall be as indicated on the Drawings, except that they shall be coordinated with the ratings of the equipment actually furnished, and shall be modified where necessary to suit the equipment. Circuit breakers to be used in motor control centers shall be as indicated on the Drawings. Where no indication of type is given on the Drawings circuit breakers protecting motors shall be motor circuit protectors, and other circuit breakers shall be molded case type.
- C. Circuit breaker for mounting in motor control centers, or for separate mounting shall be of the air-break type, quick-make and quick-break, 600 volt, with number of poles as indicated on the Drawings.
- D. Each pole of the circuit breaker shall provide inverse time delay, and instantaneous circuit protection.
- E. The breakers shall be operated by a handle, and shall have a switching mechanism that is mechanically trip free from the handle, so that the contacts cannot be held closed against short circuits, and abnormal currents. Tripping due to overload, or short circuit shall be clearly indicated by the handle automatically assuming a position between the manual

ON and OFF positions. Latch surfaces shall be ground and polished. Poles shall be constructed so that they open, close, and trip simultaneously.

- F. Breakers must be completely enclosed in a molded case. Non-interchangeable trip breakers shall have their covers sealed; interchangeable trip breakers shall have the trip unit sealed to prevent tampering. Ampere ratings shall be clearly visible. Contacts shall be non-welding silver alloy. Arc extinction must be accomplished by means of arc chutes. The minimum interrupting ratings of the circuit breakers shall be at least equal to the available short circuit current at the line terminals.
- G. Circuit breakers shall conform to the applicable requirements of NEMA Standards Publication No. AB1.
- H. Molded case circuit breakers shall be ambient temperature compensating that provides inverse time delay overload and instantaneous short circuit protection by means of a thermalmagnetic element. Compensation shall be accomplished by a secondary bi-metal that will allow the breaker to carry rated current between 25 degrees C and 50 degrees C with tripping characteristics that are approximately the same throughout this temperature range.
- I. On breakers with interchangeable, thermal, adjustable magnetic trip, the accessibility and position of the adjustment knob shall not be changed from those on the standard breaker.
- J. Unless mounted in a switchboard, or panelboard, circuit breakers shall be housed in a NEMA rated enclosure as described elsewhere in these specifications.
- K. Provide circuit breakers with shunt trip mechanisms where shown on the Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Circuit breakers shall be installed as indicated on the Drawings and per manufacturer's instructions.

End of Section

SECTION 16477

600 V FUSES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the requirements for protective fusing on this project. The Contractor shall furnish and install fuses and fuse holders per the Drawings and equipment manufacturers recommendations.
- B. This specification includes the general requirements for various types of fuses whether they are shown on the Drawings or not. If fusing is required by codes or manufacturers recommendations, but not shown on the Drawings, this specification shall apply to the type of fusing provided by the Contractor.
- C. Types of fuses specified in this section include the following:
 - 1. Class L time-delay.
 - 2. Class L fast-acting.
 - 3. Class RK1 time-delay.
 - 4. Class RK1 and Class J current-limiting.
 - 5. Class RK5 time-delay.
 - 6. Class K5 time-delay, noncurrent-limiting.
 - 7. Class T current-limiting.

1.02 QUALITY ASSURANCE

The fuse manufacturer's facilities shall be ISO 9001 certified.

1.03 CODES AND STANDARDS

- A. UL Compliance and Labeling: Comply with applicable provisions of UL 198D, "High-Interrupting-Capacity Class K Fuses". Provide over-current protective devices which are UL-listed and labeled.
- B. NEC Compliance: Comply with NEC as applicable to construction and installation of fusible devices.
- C. ANSI Compliance: Comply with applicable requirements of ANSI C97.1 "Low-Voltage Cartridge Fuses 600 Volts or Less".

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data on fuses, including specifications, electrical characteristics, installation instructions, furnished specialties and accessories in accordance with Section 16000, and the Contract Documents. In

addition, include voltages and current ratings, interrupting ratings, current limitation ratings, time-current trip characteristic curves, and mounting requirements.

1.05 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering fusible devices which may be incorporated in the work include, but are not limited to, the following:
Bussmann, Gould-Shawmut, Reliance, or equal.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics indicated, which comply with manufacturer's standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations.

2.02 CLASS L TIME-DELAY FUSES

- A. Provide UL Class L time-delay fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting transformers, motors, and circuit-breakers.

2.03 CLASS L FAST-ACTING FUSES

- A. Provide UL Class L fast-acting fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting service entrances and main feeder circuit-breakers.

2.04 CLASS RK1 TIME-DELAY FUSES

- A. Provide UL Class RK1 time-delay fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting motors and circuit-breakers.

2.05 CLASS RK1 CURRENT-LIMITING FUSES

- A. Provide UL Class RK1 current-limiting fuses rated 250-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit-breakers.

2.06 CLASS J CURRENT-LIMITING FUSES

- A. Provide UL Class J current-limiting fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating.

2.07 CLASS RK5 TIME-DELAY FUSES

- A. Provide UL Class RK5 time-delay fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting motors.

2.08 CLASS K5 ONE-TIME FUSES

- A. Provide UL Class K5 one-time fuses rated 250-volts, 60 Hz, with 100,000 RMS symmetrical interrupting current rating for protecting non-inductive loads.

2.09 CLASS T FUSES

- A. Provide UL Class T fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protection of physically small devices.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Fuse types and sizes shall be as indicated on the Drawings. Fuses shall be installed in accordance with the National Electric Code (NEC) requirements and the manufacturer's written instructions.
- B. Install fuses in proper fuse holders.
- C. Where fuses are installed in the motor starters, fuses shall be sized to match the actual motor full load current.
- D. Where fuses are installed in disconnect switches at HVAC units, the fuse sizes shall be sized to meet the HVAC manufacturer's requirements.
- E. Fuses for control transformers shall be sized in accordance with the National Electrical Code.
- F. Fuses shall be installed with the labels clearly visible.

3.02 FIELD QUALITY CONTROL

- A. Prior to energizing fusible devices, test devices for circuit continuity and for short-circuits.

3.03 SPARE PARTS

- A. Furnish 3 spare fuses of each size and type.

End of Section

SECTION 16500

LIGHTING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install lighting fixtures.

1.02 QUALITY ASSURANCE

- A. Reference Standards:
 - 1. National Electrical Code (NEC)
 - 2. UL Standard #57, Electric Lighting Fixtures
 - 3. UL Standard #844, Electric Lighting Fixtures for Use in Hazardous Location
 - 4. UL Standard #1570, Fluorescent Lighting Fixtures
 - 5. UL Standard #1571, Incandescent Lighting Fixtures
 - 6. UL Standard #1572, High Intensity Discharge Lighting Fixtures
 - 7. Illuminating Engineering Society (IES)
 - 8. All applicable local lighting ordinances
- B. Miscellaneous:
 - 1. Lamps are identified for each luminaire in the Lighting Fixture Schedule on the Drawings.
 - 2. Lighting fixtures and electrical components:
 - a. UL labeled, complete with lamps.
 - b. Rated for area classification as indicated.
 - 3. Location of lighting fixtures on Drawings are intended to be used as a guide.
 - a. Field conditions may affect actual locations.
 - b. Coordinate with other trades to avoid conflicts in mounting of fixtures and other equipment.
 - 4. The quality standard is established by the fixture listed in the Lighting Fixture Schedule.
 - a. This quality standard includes, but is not necessarily limited to construction features, materials of construction, finish, and photometrics.

1.03 SUBMITTALS

- A. The following shall be submitted to the Engineer for review:
 - 1. Acknowledgment that products submitted meet requirements of standards referenced.
 - 2. Manufacturer's technical information on products to be used including photometric performance curves for the fixture and ballast data.
 - 3. Acknowledgment that products submitted are UL or ETL listed.

4. When general data sheets constitute part of the submittal, identify the products to be used on this project.
 5. Manufacturer's installation instructions.
 6. Identification of fixtures by Lighting Fixture Schedule.
 7. UL nameplate data (Voltage, wattage, etc.).
 8. Finishes, colors, and mounting type.
 9. Pole, fixture, and accessories.
 10. Pole wind loading.
- B. Contractor shall submit shop drawings, manufacturer's data sheets, and a complete wiring diagram detailing all connections to the electrical system in accordance with Section 16000, and other requirements of the Contract Documents.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Lamps shall be manufactured by General Electric, North American/Phillips, Sylvania, or equal.
- B. Lighting fixtures shall be provided as indicated on the Lighting Fixture Schedule on the Drawings.
- C. Lighting ballasts shall be manufactured by General Electric, Advance, Jefferson, Universal, Bodine, Lithonia, or equal.
- D. Light poles shall be as indicated on the Drawings. Include base template, anchor bolts, cadmium-plated hardware and pole grounding lug, handhole, anchor base and bolt covers. Pole foundations shall be as indicated on the Drawings.

2.02 MATERIALS

- A. General:
 1. Lamps:
 - a. See lighting fixture schedule on Drawings for wattage, voltage and number required.
 2. All Fixtures:
 - a. There shall be no live parts normally exposed to contact.
 - b. When intended for use in wet area:
 - 1) Mark fixtures "suitable for wet locations."
 - c. When intended for use in damp areas:
 - 1) Mark fixtures "suitable for damp locations" or "suitable for wet locations."
 - d. In wet or damp area, install fixtures so that water cannot enter or accumulate in the wiring compartment, lampholder, or other electrical parts.
 - e. Gasket seals: Urethane foam

- f. Diffusers: UV stabilized acrylic plastic
- 3. Underground wiring:
 - a. Provide all wiring runs with separate green grounding conductor.
 - b. Ground all pole bases.
- 4. Pole wiring from base to ballast:
 - a. No. 12 type XHHW.
 - b. Each phase shall be protected by a 30A, 600V, type Tron waterproof fuseholder, Bussman "Limitron" type fuse, size rating 3-times load current.

B. Incandescent Lamps:

- 1. Types:
 - a. 30-135 watts: Energy efficient
 - b. 200-500 watts: Standard
- 2. Inside frost
- 3. Base: Aluminum or brass
- 4. PAR/Halogen

C. Fluorescent Lamps:

- 1. Rapid start
- 2. Cool white (F32T8/41K-85CRI and F96T12/41K-70CRI/HO/ES)
- 3. Energy efficient or standard as noted on the lighting fixture schedule.

D. High-Pressure Sodium Lamps:

- 1. Bulb finish: Clear
- 2. Any burning position

E. Metal Halide Lamps:

- 1. Bulb finish: Clear
- 2. Any burning position

- F. Furnish a minimum of 2 lamps, or ten percent spare lamps of each type and wattage, whichever is greater.

2.03 FIXTURES

A. Fluorescent Lighting Fixtures:

- 1. Ballast:
 - a. Rapid start, high power factor type
 - b. CBM/ETL certified
 - c. Sound rating A
 - d. Two internal automatic-resetting thermal switch devices for coil and capacitor
- 2. Internal wiring: AWM, TFN or THHN
- 3. Channel and end plates: 22 GA steel
- 4. Steel door frame and socket track: 20 GA steel
- 5. Channel cover: 24 GA steel
- 6. Emergency ballast:

- a. Integral rechargeable nickel-cadmium battery, battery charger, and automatic transfer circuitry.
 - b. Charging indicator light.
 - c. Test Switch.
 - d. Provide a minimum of 900 lumen output for 90 minutes upon loss of normal power.
 - e. Mounted integral to the fixture.
 - f. UL 924 listed.
7. Provide fixtures with emergency ballasts with permanent caution labels warning that the fixture is fed from an unswitched source.
- a. Provide emergency ballast also with a similar caution label.

B. HID Lighting Fixtures:

- 1. Ballasts for high pressure sodium lighting fixtures:
 - a. Type: Regulating
 - b. Ballast design center variance: Maximum 5 percent from rated lamp wattage.
 - c. Lamp wattage regulation spread at the lamp voltage: Maximum 10 percent for +/-10 percent line voltage variation.
 - d. Ballast primary current during starting not to exceed normal operating current.
 - e. Lamp current crest factor: Maximum 1.8 for +/-10 percent line voltage variation at any lamp voltage, from nominal through life.
 - f. Power factor shall not drop below 90 percent for +/-10 percent line voltage variations at any lamp voltage, from nominal through life.
 - g. Capacitor variance: Tolerance of +/-6 percent which will not cause more than a +/-8 percent variation in regulation throughout rated lamp life for nominal line voltage.
 - h. Capable of operation with an open circuit condition for a maximum of 6 months without significant loss of ballast or starting circuitry life.
- 2. Ballasts for metal halide/mercury vapor lighting fixtures:
 - a. Type: Auto-regulator
 - b. Voltage input range: +/-10 percent
 - c. Lamp regulation spread: 20 percent maximum
 - d. Power factor: 90 to 95 percent
 - e. Input voltage dip (4sec.): 40 to 50 percent
 - f. Crest factor of lamp current: 1.6 to 2.0
- 3. Ballasts for exterior HID lamps:
 - a. UL approved
 - b. High power factor designed for -20 Deg F temperature starting
- 4. Fixtures for non-hazardous locations:
 - a. Type: Industrial low bay
 - b. Ballast housing: Die-cast
 - c. Filter: Activated charcoal
 - d. Refractor: UV stabilized molded acrylic

2.04 MISCELLANEOUS ELECTRIC DEVICES

- A. PHOTOELECTRIC CONTROL UNITS shall meet the following requirements:
 - 1. Cadmium sulfide photocell
 - 2. Aluminum weatherproof enclosure
 - 3. 30 amp rated contacts
 - 4. 120-volt AC power
 - 5. The Photoelectric control unit shall be Tork Model 2100, or equal.
- B. MOTION SENSORS shall meet the following requirements:
 - 1. 110 degrees field of view, 60 foot range
 - 2. Adjustable time setting from 15 seconds to 15 minutes
 - 3. Operating temperature of -20 to + 130 degrees F.
 - 4. Complete outdoor, weather proof sensor with complete mounting hardware
 - 5. UL listed
 - 6. The motion sensor(s) shall be manufactured by Leviton Model 50500-H or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install lamps in all luminaires.
- B. Replace all failed fluorescent, incandescent, metal halide, mercury vapor and high pressure sodium lamps with new lamps prior to final acceptance by Owner.
- C. Surface and flush mounted fixtures shall be solidly connected to a junction box. Suspended fixtures shall be hung utilizing pendant mounting or stainless steel chains and hooks. Each suspended fixtures, shall be electrically connected by a length of Type SO flexible cord. 3 conductor No. 14 AWG, minimum, with a twist-lock receptacle mounted in an individual junction box. Plugs and receptacles shall be as manufactured by Hubbell, General Electric Company, or equal.
- D. Provide mounting brackets and/or structural mounting support for fixtures.
 - 1. Do not support fixture from conduit system.
 - 2. Do not support fixture from outlet boxes.
- E. Install with approved mounting hardware following manufacturer's recommendations.
- F. Pole mounted fixtures shall be mounted on steel or aluminum poles as indicated on the Drawings. All metal poles shall be bonded to the facility ground system. Poles shall have adequate handholes and weatherproof receptacles where indicated.
- G. All anchor bolts and nuts shall be stainless steel. Contractor shall paint all steel poles with aluminum paint or other color in accordance with these Contract Documents.

- H. Fixture mounting heights and locations indicated on the Drawings are approximate and are subject to revision in the field where necessary to avoid conflicts and obstructions.

3.02 ADJUSTING AND CLEANING

- A. Wipe all lighting fixture reflectors, lenses, lamps, and trims clean after installation and prior to acceptance of Project by Owner.

End of Section

SECTION 16505

TRANSIENT VOLTAGE SURGE SUPPRESSION SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section specifies Transient Voltage Surge Suppression (TVSS) System(s).

1.02 SUBMITTALS

- A. Submit manufacturer's data demonstrating compliance with this specification and the Drawings. Information shall include, but not be limited to:
 - 1. An equipment manual with installation, operation, and maintenance instructions for the specified unit.
 - 2. A list of customer-replaceable spare parts.
 - 3. Electrical and mechanical drawings which show unit dimensions, weights, mounting provisions, connection details and layout diagram of the unit.
 - 4. Certification of the MCOV 1-hour burn-in.
 - 5. Certification from an independent laboratory of single-pulse surge current ratings.
 - 6. A copy the UL 1449 compliance document showing UL 1449 Suppression Ratings.
 - 7. Certification of life-expectancy testing.

1.03 QUALITY ASSURANCE

- A. Comply to the following Codes and Standards:
 - 1. ANSI/IEEE (C62.41-1991 and C62.45-1987);
 - 2. NFPA (70 [NEC], 75 and 78);
 - 3. NEMA (LS-1-1992);
 - 4. NEC (240-21 and 110-9);
 - 5. All units shall be UL 1449 and UL 1283 Listed.
- B. The specified system(s) shall be manufactured in the USA by a manufacturer engaged in the design and manufacture of the specified system for a minimum of 5 years.

1.04 WARRANTY

- A. The manufacturer shall provide a Limited Five (5) Year Warranty from date of shipment against failure when installed in compliance with applicable national and local electrical codes and the manufacturer's Installation, Operation and Maintenance Instructions.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable.
1. Current Technology
 2. Liebert
 3. Advanced Protection Technologies
 4. or Equal.

2.02 ELECTRICAL REQUIREMENTS

- A. Provide TVSS units as indicated on the Drawings and specified herein.
- B. The maximum continuous operating voltage (MCOV) of all suppression components utilized in all units shall not be less than 115 % of the nominal operating voltage for 277/480 volt nominal systems.
- C. In accordance with NEMA Standard LS 1-1992, the unit shall provide protection in all modes. The primary mode of protection shall be line-to-neutral. The secondary modes of protection shall be line-to-ground and neutral-to-ground.
- D. Based on ANSI/IEEE C62.41-1991's 8 x 20 microsecond current waveform, and in accordance with NEMA Standard LS 1-1992, the tested single-pulse surge current capacity for each mode of protection of the units (in amps) shall be no less than as follows:

SURGE CURRENT CAPACITY				
PRODUCT	AMP CLASS (L-N + L-G)	L-N	L-G	N-G
MAIN TVSS	250,000	150,000	100,000	100,000
SURGE CURRENT CAPACITY				
PRODUCT	AMP CLASS (L-N + L-G)	L-N	L-G	N-G
PANELBOARD TVSS	160,000	80,000	80,000	80,000

- E. The unit's published performance ratings shall be the UL 1449 Listed suppressed ratings. The UL 1449 suppressed rating shall be, for each mode of protection, as follows:

PRODUCT	VOLTAGE	UL 1449 SUPPRESSION RATING		
		L-N	L-G	N-G
MAIN TVSS	277/480	1,000	1,000	800
PRODUCT	VOLTAGE	UL 1449 SUPPRESSION RATING		
		L-N	L-G	N-G
PANELBOARD TVSS	277/480 Three Phase	1,000	1,000	800

PANELBOARD TVSS	120/208 Three Phase	500	500	500
PANELBOARD TVSS	120/240 Single Phase	500	500	500

- F. The system shall be tested and capable of protecting against and surviving at least 6,000 ANSI/IEEE C62.41-1991 Category C3 surges without failing or degrading the UL 1449 Surge Suppression Ratings by more than 5%.

2.03 PRODUCT

- A. Each unit shall include solid-state suppression system, utilizing a multitude of selenium cells, avalanche diodes, or arrays of fused non-linear voltage dependent metal oxide varistors (MOVs) with similar operating characteristics.
- B. The suppression system's components shall optimally share surge currents in a seamless, low-stress manner assuring maximum, non-degrading voltage clamping and surge current diversion performance and proven reliability. The suppression system shall contain field replaceable fuses.
- C. The unit shall include a high-frequency extended range tracking filter and shall be UL 1283 Listed as an Electromagnetic Interference Filter. The filter shall reduce fast rise-time, high-frequency, error-producing transients and electrical line noise to harmless level, thus eliminating disturbances which may lead to system upset. Standardized insertion loss data shall be obtained using MIL-STD-E220A 50 ohm insertion loss methodology. The filter shall provide attenuation throughout the frequency spectrum of 100 kHz to 100 MHz.
- D. All internal connections associated with the suppression and filter system and subject to surge currents shall be made with compression solderless-type lugs. No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be hardwired with connections utilizing low impedance conductors and compression fittings. Internal wiring associated with the suppression/filter system and subject to surge currents shall utilize low-impedance copper bus bar and #4 AWG copper conductor or larger.
- E. Field Connections: The TVSS shall include mechanical lugs for each phase, neutral and ground. The lugs shall accommodate the conductor sized indicated on the Drawings.
- F. Each unit shall include solid-state, long-life, externally mounted LED visual status indicators that indicate the diagnostic status of the following groups of suppression modules:
1. Line to Neutral
 2. Line to Ground
 3. Neutral to Ground

- G. Each TVSS shall include a disturbance counter for both common mode (L-G) and normal mode (L-N). The Disturbance Counters shall contain-lithium batteries and a reset function.
- H. Each current-carrying ungrounded circuit conductor connected to the facility's distribution system shall be individually fused with 200,000 AIC rated fuses (One 200,000 AIC Fuse Per Phase) in order to provide maximum fault current protection.

PART 3 - EXECUTION

3.01 FIELD INSTALLATION

- A. Each unit shall be installed adjacent to the electrical equipment as indicated on the Drawings, avoiding unnecessary bends, in accordance with applicable national and local electrical codes, and the manufacturer's recommended installation instructions.

3.02 CERTIFICATION OF ON-LINE STATUS AND SUPPRESSION LEVELS

- A. The Contractor shall submit the test results to the Engineer.

End of Section

SECTION 16902

ELECTRICAL CONTROLS, RELAYS, AND ALARMS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This Section includes the following:
 - 1. Pushbutton and Selector Switches
 - 2. Relays
 - 3. Alarms
 - 4. Intrinsic Safety Barriers
 - 5. Wireways
 - 6. Watthour Transducers
 - 7. Elapsed Time Meters and Time Clocks

1.02 RELATED SECTIONS

- A. Section 16000 - General Electrical Requirements
- B. Section 16160 - Enclosures

1.03 REFERENCES

- A. NEMA ICS 1 - General Standards for Industrial Control Systems.
- B. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.
- C. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
- D. NEMA ST 1 - Standard for Specialty Transformers (Except General purpose Type).

1.04 SUBMITTALS

- A. Data - a complete list of equipment and material including manufacturer's descriptive data and technical literature, performance charts, catalog cuts and installation instructions, spare parts data for each different item of equipment specified. The data shall include a complete Bill of Materials.
- B. Drawings - containing complete wiring and schematic diagrams, control diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout, anchorage, support and appurtenances of equipment and equipment relationship to other parts of the work including clearances for maintenance and operations.

- C. Submit shop drawings in accordance with the Contract Documents, and NEMA ICS 1 specifications indicating control panel layouts, wiring connections and diagrams, dimensions, support points.

1.05 PROJECT RECORD DOCUMENTS

- A. Submit record documents in accordance with the Contract Documents.
- B. Accurately record actual locations of control equipment. Revise diagrams included in Drawings to reflect actual control device connections.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation data in accordance with the Contract Documents.
- B. Include instructions for adjusting and resetting time delay relays, timers, and counters.
- C. Submit maintenance data in accordance with the Contract Documents.
- D. Include recommended preventative maintenance procedures and materials.

PART 2 - PRODUCTS

2.01 PUSHBUTTONS AND SELECTOR SWITCHES

- A. Pushbuttons, pilot lights and selector switches shall be of the full size, heavy-duty industrial, oil tight, 120 volt, with interchangeable pilot lights, plug-in construction, double break silver contacts, chrome plated lock rings, with modular contacts, and NEMA rating equal to that of the enclosure on which devices are installed. All components shall be flush mounted on front of panel, unless otherwise noted.
- B. Provide individual legend plates for indication of switch, pushbutton, and light function (e.g., Open, Closed, Hand-Off-Auto). A list shall be submitted for review and approval.
- C. Pilot lights shall be high intensity LED type. Pilot lights shall have clear lenses and LED lamps colored as shown on the Drawings. Common, remote push-to-test circuitry shall be provided for each control panel to simultaneously test all indicating lights on the panel using a single pushbutton when there are 10 or more lights on the panel. Control panels with less than 10 lights shall utilize individual push-to-test lights and control circuitry.
- D. Pushbuttons shall be maintained or momentary as required and as shown on the Drawings. Provide extended head pushbutton for all stop functions, mushroom head for emergency stop functions, and flush head pushbuttons for all other functions. Where indicated on the Drawings pushbuttons shall be illuminated type. Provide locking mechanism for all lock out functions. Selector switches shall have black knob operator, be maintained contact type unless noted otherwise, number and arrangement as required

to perform intended functions specified but not less than one double pole, double throw, double break contact per switch. Contact rating shall be compatible with AC or DC throughput current of devices simultaneously operated by the switch contact but not less than 10 amperes resistive at 120 volts AC or DC continuous.

- E. Potentiometers shall be provided with operators and resistive elements of the type and quantity indicated on the Drawings and as required with legend plates indicating percent of span.
- F. The above devices shall be manufactured by Square D, Allen Bradley, General Electric, or equal.

2.02 RELAYS

- A. TIMING RELAYS shall be heavy duty, have 250V/5A rated contacts, solid state design, poles as required per application, -10°C to +60°C, have timing repeatability of $\pm 2.0\%$ of setting, and be UL listed. The range shall be determined from the control descriptions and or schematic drawings. Provide mounting accessories, as required. The timing relays shall be manufactured by Allen Bradley, Square D, Cutler Hammer, or equal.
- B. CONTROL RELAYS shall be of the plug-in socket base type with dust-proof plastic enclosures, with silver-cadmium oxide contacts rated 250-volt, 10 amperes, with contact arrangement and operating coils of the proper voltage as required by the control circuit sequence. Relays shall have indicating lamp to show energized state. Each relay shall have a minimum of two double pole, double throw contacts, or as required. Control relays shall be Allen Bradley, Square D, Cutler Hammer, or equal.
- C. ALTERNATING RELAYS shall be UL listed, 120 VAC, with contacts rated for 10 amperes at 250 VAC, life expectancy of 100,000 operations, load indicating LEDs, and switch for load locking and load selecting options. Alternating relays shall be manufactured by TimeMark models 261, 271, and 471, Diversified Electronics model ARA, A.T.C. model "AR", or equal.

2.03 ALARMS

- A. AUDIBLE ALARMS shall be UL listed, 120 VAC, with solid state circuitry, vibrating horn, non-metallic corrosion resistant housing, with required mounting hardware, suitable for outdoor use capable of producing 100 dB at 10 feet. The audible alarm shall be manufactured by Federal Signal model 350, Edwards model 870-EX, or equal.
- B. ROTATING BEACONS for interior and/or exterior locations shall be UL listed, 120 VAC, with motor and cooling fan, rotating lights at 60 times per minute minimum, capable of producing 36000 candlepower with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Federal Signal model 371L or equal.

- C. ROTATING BEACONS for corrosive and/or hazardous locations shall be UL listed, 120 VAC, with solid state circuitry, rotating lights at 60 times per minute minimum, suitable for outdoor use capable of producing 36000 candlepower with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Edwards model 52EX or equal.
- D. STROBE BEACONS shall be UL listed, NEMA 4X, 120 VAC, flashing at 80 times per minute minimum, producing peak candlepower of 520,000, effective candlepower of 165, with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Federal Signal model 151XST, Edwards model 92EX, or equal.

2.04 INTRINSIC SAFETY BARRIERS

- A. INTRINSIC SAFETY BARRIERS shall permit connection of devices located in a hazardous area to other devices located in a safe area. Intrinsic safety barriers shall be EMC compliant, 10 to 35 V dc, 35 mA output current, hazardous area terminals identified by blue labels, terminals accommodating conductors up to 12 AWG, ambient temperature rating of -20 to +60°C. The intrinsic safety barriers shall be manufactured by MTL Inc., Ronan Engineering Co., R. Stahl Inc., A.T.C., or equal.

2.05 WIREWAYS

- A. WIREWAYS shall be PVC, snap-in slot design, with non-slip cover. Safe area wireways shall be light gray and marked "Safe Area Wiring." Hazardous area wireways shall be intrinsic blue and marked "Hazardous Area Wiring." The wireways shall be manufactured by Panduit Corporation, or equal.

2.06 WATTHOUR TRANSDUCERS

- A. WATTHOUR TRANSDUCERS for active or reactive power shall be DIN rail and surface mount, single phase or three phase with balanced or unbalanced load, electrically isolated input and output signals, 4 to 20 mA output signal, 0-10 mA to 0-10 A input current, 0-10 V to 0-600 VAC input voltage, 16-500 Hz selectable frequency. The watthour transducers shall be manufactured by Sineax model PQ502, or equal.

2.07 ELAPSED TIME METERS AND TIME CLOCKS

- A. ELAPSED TIME METERS shall be self powered, non-reset, solid state counter which provides silent, accurate and noise immune operation. Elapsed time meters shall require no external power, five year minimum battery life, 120 VAC power, accessories for panel mounting, nameplate below LCD display reading "HOURS", liquid crystal display with 6 digits approximately 2 inches high with 50,000 hour minimum display life and indication of sufficient battery power. The elapsed time meters shall be manufactured by Durant, Automatic Timing and Controls a Division of Sycon Corp., or equal.

- B. TIME CLOCKS shall be microprocessor based, have 24 hour time control, up to 24 operations per day, programmable from panel face keys, skip-a-day feature allowing schedule to be skipped for one to seven days, SPDT switch contact rated at 15 amps at 120 V AC, with battery carryover to maintain time and program during power outage for 275 hours. The time clocks shall be manufactured by Tork, Paragon Electric Company, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Fasteners shall be type 304 stainless steel.
- B. Install devices in strict accordance with NEC requirements and per manufacturers recommendation.
- C. Coordinate with other trades as necessary during installation of these devices.

3.02 ACCEPTANCE

- A. All installations are subject to evaluation in accordance with NEC requirements and manufacturers recommendations. Contractor shall remove the unacceptable work and correct work at no charge to Owner.

End of Section

SECTION 16907

PROGRAMMING & CONTROL DESCRIPTION

PART 1 - GENERAL

1.01 PLC DIAGNOSTICS

- A. Configure the PLC programs and OI to monitor the diagnostic registers in the PLC. Create special diagnostic screens at the OI to display the status of these registers, and provide alarms of a PLC diagnostic failure. The following diagnostic status words shall be monitored:
 - 1. Module status, and module failures.
 - 2. Internal battery condition.
 - 3. Power supply status.

1.02 PLC APPLICATION PROGRAMMING SOFTWARE

- A. Refer to the Contract Documents and P&IDs for the process control descriptions and functional requirements to be implemented using the following application software packages.
 - 1. Furnish and install complete packages of the latest version of PLC Programming Software and OI Configuration Software.
 - 2. PLC Programming
 - a. Submit 2 copies of the PLC programs for review, prior to installation. The relay ladder logic programs shall be fully documented with unique symbol names for each program element (coils, contacts, inputs, outputs, etc.), and comments for every 3 rungs of logic. The rung comments shall clearly describe the function of the logic, so that another Programmer can understand the logic and be able to debug and modify the programs at a later date.
 - b. Once the programs have been reviewed, comments and changes shall be incorporated into the programs and submitted for a final review. Upon final review of the programs, install the programs in the PLCs to test the control logic using simulated I/O.
 - c. Provide instruction, maintenance manuals and diagrams for supplied programs, device drivers, and custom designed subprograms and device drivers developed for this project. Provide all materials in one or more three-ring binders. Separate sections by laminated numbered or descriptive tabs, with a table of contents to aid the user in finding specific information. Three-ring binders shall have labels on the spine identifying the contents of each volume.
 - 3. Submit a training schedule in accordance with these Specifications.
 - 4. Submittals shall be complete, neat and orderly.
 - 5. Submit two 3½ inch floppy disk copies of the PLC and OI software programming in their final configuration. Also, submit all original software registered in the

Owner's name, and all original documentation that accompanies the original software diskettes.

1.03 ON-SITE TRAINING

- A. Arrange for instruction of the Owner's designated personnel. The instruction shall commence within 30 days of Owner request. Training shall include a minimum of 8 hours of owner training.
- B. The Owner reserves the right to split training periods to accommodate personnel schedules.
- C. The training sessions shall be structured to provide the Owner's personnel with a maximum of hands-on experience.
- D. Control System Overview training shall consist of the following topics:
 - 1. Definition of control modes such as AUTO, MANUAL, LOCAL, and REMOTE.
 - 2. Entering and changing set points.
- E. Provide the Owner with the ability to program the PLCs, add new network components and PLCs as needed for future expansion of the system, and update or modify any OI Screen to accommodate future expansion.

1.04 START-UP SUPPORT

- A. The Contractor shall have field service and programming personnel on-site to provide start-up and commissioning services for a period of at least 5 days. The start-up service shall be coordinated with the Engineer. The start-up service shall be required prior to starting the final acceptance test.

1.05 PROGRAMMING SUPPORT

- A. The Contractor shall be available to provide programming services for a period of at least 15 days. The start of this service shall commence after successful completion of the final acceptance test. This service shall consist of:
 - 1. Furnishing additional programming that may be required.
 - 2. Assisting Owner's personnel with additional technical support and training.

1.06 FACTORY WITNESS TESTING

- A. Hardware and software components of the PLC System shall be thoroughly tested and "burned in" at the factory by the Contractor. Inform the Engineer 10 working days prior to the testing of the equipment. The Engineer and Owner shall witness these tests before shipment to the site. Provide copies of all test reports to the Engineer.
- B. The Contractor shall be responsible for all transportation, meals, accommodation expenses for the Owner's and Engineer's representative witnessing the factory test.

1.07 ON-SITE TESTING

- A. On-site testing of the PLC system shall be performed prior to the final acceptance test. Submit a testing schedule detailing the timing and extent of the proposed testing and the test procedures to be followed.
- B. Prior to the final acceptance test, the Engineer will review the status of the PLC system and determine if the final acceptance test can be performed. All primary elements shall be calibrated and all I/O signals shall be fully functional prior to the start of the final acceptance test.
- C. Perform the PLC system final acceptance test and confirm the operation of all control loops, primary elements, control functions and sequences, and monitoring functions required of the complete PLC system. The PLC and OI shall be operated continuously throughout the test without software or hardware failure. In the event of a failure, the acceptance test shall be terminated, the hardware or software failure shall be corrected, and the acceptance test shall be restarted. The Engineer and the Owner shall determine if it is necessary to restart the test at the first day of the test. The final acceptance test shall run uninterrupted for seven (7) calendar days.

1.08 GENERAL PROGRAMMING REQUIREMENTS

- A. The software development and programming of the control functions described herein shall be completed by the date defined in the Contract Documents. PLC programs and OI configuration software shall meet the performance requirements described herein, and the control needs of the Owner.
- B. The control descriptions provided herein do not provide every programming detail such as timers, function blocks, coils, contacts, or other relay ladder logic elements that are required to write and implement complete PLC programs. The control descriptions are intended to describe the overall functional capability of the particular process being described. Communication with the Owner and the Engineer shall be necessary to convey the additional information needed to produce the working PLC programs.
- C. Any discrepancies in these documents shall be brought to the attention of the Engineer, in writing. The Engineer will then issue further explanation. The decision of the Engineer will be final.
- D. Control logic shall be programmed, furnished, and installed as specified. The Contractor shall be required to test and demonstrate to the satisfaction of the Engineer that the control logic functions as specified.
- E. The PLC programs shall meet industry norms, and function in such a way as to maintain safe and reliable operation of the equipment they are designed to control. If the Engineer determines that the control logic and PLC programming fails to perform the functions described herein in a safe and reliable manner, the Contractor shall modify and correct the programs.

- F. Set points for analog control loops shall be displayed in digital form on the screen, similar to a single loop controller display. Additionally:
1. Automatic and manual loop control shall be available.
 2. The display will show the current set point, current output value, and the current process variable input values for each respective control loop.
 3. The operator shall be able to take the loop out of the automatic mode, and drive the output signal manually from the OI. The transfer from automatic to manual shall be "bumpless".
 4. PLC Analog loops with PID (proportional, integral, and derivative) control shall be tunable from the OI. Tuning of the PID loops shall be completed before Substantial Completion. The PID loops shall meet the following performance requirements:
 - a. No more than two major process variable overshoots shall be permitted after a process upset, or a set point change. The peak overshoot shall not exceed the process variable set point value by more than 7 percent of its value.
 - b. A major process variable overshoot is defined as a process variable time-domain measurement that exceeds the process variable set point by more than ± 2 percent of the set point's value.
 - c. The process variable shall settle to within ± 2 percent of the set point value within a period of time (or oscillation) that is acceptable for the process control application, and as defined by the Engineer. The period of oscillation shall be adjustable by tuning the integral rate (or reset rate) of the PID loop.
- G. Integer or floating point values, from analog or totalized tags, shall be formatted to display at least three (3) significant digits. For example, a tank level value shall be displayed as "13.6 FEET", or a pump flow rate shall be displayed as "1,575 GPM".
- H. The PLC shall not be able to control any equipment item that is not in the AUTO or REMOTE mode.
- I. The PLCs shall be programmed to monitor each of their respective analog signal inputs for instrument failures. If the input signal falls below 4 milliamps due to a short circuit, or an open current loop, the PLC shall produce an alarm signal to the OI.
- J. All motorized equipment (i.e. Wells and Pumps) will have Accumulation Runtime Counters associated with them.

PART 2 - CONTROL DESCRIPTIONS

2.01 GENERAL DESCRIPTION (WORK IN PROGRESS)

- A. A 700HP well pump No.1 (PMP-100) will supply remote Reservoir No.1 using Hand-Off-Auto controls. In the Auto mode, Well Pump No.1 will be controlled by reservoir level. The reservoir will use a level transmitter as primary level control and a float switch as backup for high high level alarm. Well pump No.1 will be controlled by a Medium Voltage Solid State Starter and will employ Pump-to-Waste controls using two

solenoid operated valves. Chlorine treatment will be accomplished via a chlorinator and dual chlorine cylinders.

2.02 PERMISSIVES

A. To run the well pump in either Auto or Hand mode certain conditions must be met.

1. Well pump No.1 permissives:
 - a. Pump-to-Waste valve open.
 - b. Reservoir valve shut.
 - c. No reservoir HIGH HIGH level.
 - d. Backspin timer has elapsed.
 - e. No high discharge pressure of well pump.
 - f. No incomplete valve sequence alarm
 - g. No Soft Starter fault

2.03 WELL PUMP NO.1 START/STOP SETPOINTS (AUTO MODE)

1. Start - Level Transmitter (LOW)
2. Stop - Level Transmitter (HIGH)
3. Stop - Float Switch backup (HIGH HIGH)

2.04 MANUAL OPERATION

A. In Hand mode, Well Pump No.1 will be controlled by the operator. The operator will have Stop, Start and Reset buttons on the local control panel for control.

2.05 AUTO OPERATION

A. In Auto mode, Well Pump No.1 will be controlled by the level in the reservoir. Level will be transmitted from Reservoir No.1 as a 4-20 mA signal to the PLC (PLC-100). Well pump Stop/Start setpoints corresponding to the appropriate 4-20 mA signal level will be programmed into the PLC.

1. Normal Operation:
 - a. The PLC will output a start command when reservoir level drops to a predetermined start setpoint(LOW). Assuming all of the above permissives are met, the well pump will start and reservoir level will start to increase.
 - b. When reservoir level increases to its predetermined stop setpoint(HIGH), the PLC will output a command to stop the well pump.
2. Backup Operation:
 - a. In the event that the level transmitter fails, reservoir level will continue to increase until it reaches the HIGH HIGH level. At this level a float switch will transmit the HIGH HIGH condition to the PLC. The PLC will then output a signal to stop the well pump.
3. Loss of Communications Operation:
 - a. In the event of loss of communications with Reservoir No.1, the PLC will perform the following function to allow the pump to run as long as possible without overflowing Reservoir No.1.

- 1) A PLC function (F(X)) will include a time delay in the event that communication with Reservoir No.1 is restored and normal operation continues.
- 2) The PLC function (F(X)) will take the last level signal(X) from the reservoir as an input.
- 3) The PLC function F((X)) will calculate the total volume(V) to fill the reservoir up to the HIGH level setpoint via the following: $F(X) = V = \text{Pi} * \text{Radius}^2 * (\text{HIGH level setpoint} - X)$.
- 4) Another PLC function will calculate a TIME(T) variable. The TIME variable will determine the amount of time it will take to fill the reservoir up to the HIGH level setpoint given a well pump flowrate by the following: $\text{Time} = T = V / \text{Flowrate}$.
- 5) The TIME variable will be placed into a counter. When the counter has elapsed the PLC will send a STOP signal to Well Pump No.1.

2.06 PUMP-TO-WASTE CYCLE

1. When the reservoir level drops to a pre-determined 'LOW' level setpoint(as stated above), the well pump will turn on and start pumping to waste via a normally open solenoid operated pump-to-waste valve.
2. After the pump-to-waste cycle timer has elapsed, a normally closed solenoid-operated Reservoir Valve will open to allow flow into the Reservoir.
3. After the Reservoir Valve is fully open, the Pump-to-Waste valve will shut allowing full rated flow into the reservoir via the Reservoir Valve.
4. When the reservoir fills to a pre-determined 'HIGH' level setpoint, the well pump will start its shutdown sequence.
5. The Pump-to-Waste valve will open.
6. The Reservoir Valve will shut.
7. When Reservoir Control Valve indicates shut, the well pump will shut down.

2.07 INSTRUMENTS

1. PSH-100 - High pressure switch: Shuts down Well Pump No.1 on high pressure.
2. FQIT-100 - Magnetic Flowmeter: Measures well pump flowrate and totalizes flow.
3. SOV-102 - Solenoid Operated Lube Oil Valve: Opens to start lube oil flow when Well Pump No.1 start command is given.
4. AE-201 - Chlorination enclosure leak detect sensor: Monitors chlorine concentration within the chlorination enclosure.

2.08 CHLORINATION SYSTEM

1. The chlorination system consists of a Chlorine Booster Pump (PMP-200), an injector, chlorinator and dual chlorine cylinders.
2. The Chlorine Booster Pump will have HAND-OFF-AUTO controls.
3. The chlorine injection rate will be manually adjusted via a rotometer on the chlorinator panel.
4. Chlorine injection will start automatically when the Chlorine Booster Pump starts.

5. The Chlorine Booster Pump permissives are Well Pump No.1 running and Reservoir Flow valve open. In both HAND and AUTO mode, the Chlorine booster pump will NOT start unless these two conditions are met.
6. Chlorine injection will stop automatically when the Chlorine Booster Pump stops.
7. Chlorine Booster Pump will stop when Well Pump No.1 stops.
8. The following are the chlorination system alarms:
 - a. Chlorine leak detection low alarm.
 - b. Chlorine leak detection high alarm.
 - c. Loss of chlorine sensor input alarm.

2.09 ALARMS

1. Well Pump No.1 soft start will communicate the following alarms to the PLC:
 - a. WELL PUMP NO.1 FAULT. This alarm will be communicated when any of the following conditions occur: Motor overload, Solid State Starter fault, High Pressure alarm, Valve incomplete sequence, etc. refer to P&ID for more information.
 - b. WELL PUMP NO.1 VALVE INCOMPLETE SEQUENCE. This alarm will be communicated when the Pump-to-Waste valve does not close OR the Reservoir valve does not open within their respective predetermined travel time
 - c. WELL PUMP NO.1 HIGH PRESSURE. This alarm will be communicated when Well Pump No. 1 discharge pressure exceeds the discharge pressure alarm setpoint.

End of Section

SECTION 16920

ELECTRICAL ACCEPTANCE TESTING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes

1. Requirements for electrical acceptance testing of electrical equipment and materials.
2. It is the intent of the tests described herein to assure that all electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.
3. Acceptance testing performed by equipment vendors at the point of manufacturer must conform to all requirements of this specification. Testing performed at the point of manufacture which conforms to generally accepted industry practices is also acceptable so long as adequate test result documentation is provided.

B. Scope

1. All of the Acceptance Tests are required to be performed whether they are described in this Section or other applicable Sections. At a minimum, the following electrical systems are to be tested:
 - a. Service Entrance Section
 - b. Main Distribution Panel
 - c. Motor Control Centers
 - d. Switchgear, Low and Medium Voltage
 - e. Panelboards, Power and Lighting/Receptacle
 - f. Transformers, Dry Type and Oil Filled
 - g. Feeders
 - h. Cables rated 600 volts and higher
 - i. Transfer Switches, Manual and Automatic
 - j. Transient Voltage Surge Suppression Systems
 - k. Grounding and Bonding System
 - l. Lighting Fixtures and associated controls
 - m. Other systems as listed under Part 3 of this specification

C. Related Documents

1. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 1 Specification sections, apply to the work of this section.
2. All work performed under this Section of the work is subject to all requirements contained under Section 16000 "General Electrical Requirements".
3. All Division 16 specifications for electrical equipment provided for this project that requires electrical acceptance testing.

1.02 REFERENCES

- A. NETA ATS – Acceptance Testing Specifications, 2003 Edition
- B. NFPA 70 – National Electrical Code, 1999 Edition
- C. Incorporated by reference all Codes, Standards, and Specifications referred to in the “APPLICABLE REFERENCES” section of NETA ATS-2003.

1.03 DEFINITIONS

- A. NETA InterNational Electrical Testing Association Inc.
- B. NEC National Electrical Code

1.04 SYSTEM DESCRIPTION

- A. Conditions
 - 1. Provide all items, articles, materials, operations or methods listed, mentioned or scheduled on drawings and/or herein including all labor, materials, equipment and incidentals necessary and required for Electrical Acceptance Testing.
 - 2. Following established procedures, equipment shall be energized after certification by the testing organization that the installation is satisfactory.
 - 3. Correct or replace any current-carrying circuit, electrical equipment, or system which is defective or grounded and correct all other troubles encountered by these tests. All defects, whether through faulty workmanship or materials furnished, shall be corrected under this Section at the Contractors expense.

1.05 SUBMITTALS

- A. Test Report Forms
 - 1. All test reports shall be submitted using NETA or approved similar format and, where appropriate, test forms. Reports shall be legible using permanent ink. Pencil is not acceptable.
 - 2. Provide for engineers review and approval a copy of each test form to be used on the project. No testing shall be started prior to approval of all test forms.
 - 3. All test reports shall include the following information:
 - a. Summary/Description of the Project
 - b. Description of equipment tested.
 - c. Description of the tests.
 - d. Test data and analysis of the data indicating whether the equipment passed or failed the test.
 - 4. All test data records shall include the following minimum requirements:
 - a. Equipment identification including tag numbers.
 - b. Humidity, temperature, and other conditions that may affect the results of the tests and/or calibrations.
 - c. Date of inspections, tests, maintenance, and/or calibrations.

- d. Identification of the testing technician and their employer.
- e. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
- f. Indication of expected results when calibrations are to be performed.
- g. Indication of "as-found" and "as-left" results, as applicable.
- h. Sufficient spaces to allow all results and comments to be indicated..

B. Closeout Submittals

- 1. Provide one copy each to engineer and owner of all testing reports organized as follows:
 - a. Bind report in 3-ring binder(s).
 - b. Identify project name, description, testing organizations name, and submittal date on front face and back cover of binder.
 - c. Provide all test reports, organized by equipment tag number.
 - d. Separate different equipment numbers with colored or numbered tabs.
 - e. Provide an index/table of contents.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Any materials provided as part of the testing shall be new, unused, and in manufacturer's original packing.

2.02 TEST INSTRUMENT CALIBRATION

- A. Contractor performing the testing shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy for each test instrument calibrated.
- B. Contractor performing the testing shall maintain up-to-date instrument calibration instructions and procedures for each test instrument calibrated.
- C. It is preferred that instrument calibration accuracy be directly traceable to the National Institute of Standards and Technology (NIST).
- D. Instruments shall be calibrated in accordance with the following frequency schedule:
 - 1. Field instruments: Analog, 6 months maximum. Digital, 12 months maximum
 - 2. Laboratory instruments: 12 months maximum
 - 3. Leased specialty equipment: 12 months maximum.
- E. Dated calibration labels shall be visible on all test equipment.
- F. Records, which show date and results of instruments calibrated or tested, must be kept up to date.

- G. Calibrating standard shall be better accuracy than that of the instrument tested.

PART 3 - EXECUTION

3.01 QUALIFICATIONS

- A. It is preferred that the testing organization shall be an independent, third party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated. When such testing organization is used, it must meet the following requirements:
1. The testing organization shall be regularly engaged in the testing of electrical equipment, devices, installations, and systems.
 2. The testing organization shall use technicians who are regularly employed for testing purposes.
 3. The testing organization shall be a member of NETA or be able to prove qualifications equal to or better than required for membership in NETA.
 4. Submit appropriate documentation demonstrating that the testing organization meets the requirements listed above.
 5. Technicians performing these electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make a judgment on the serviceability of the specific equipment.
 6. Technicians shall be certified in accordance with ANSI/NETA ETT-2000, "Standard for Certification of Electrical Testing Personnel". Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.
- B. Contractor may perform the electrical acceptance testing under the following conditions:
1. Contractor's personnel performing the testing and their testing equipment meets all other requirements of this specification.
 2. Written approval is received from engineer after review of testing personnel qualifications. At a minimum, contractor's testing personnel must have specific instruction on the testing instruments, accessories, and tests being performed and must be able to evaluate the test results.

3.02 NOTIFICATION

- A. Notify engineer and construction manager at least 2 days prior to testing so that they may be present during testing.

3.03 SAFETY AND PRECAUTIONS

- A. Safety practices shall include, but are not limited to, the following requirements:
1. Occupational Safety and Health Act OSHA
 2. Accident Prevention Manual for Industrial Operations, National Safety Council, Chapter 4

3. Applicable State and Local safety operating procedures
4. NETA Safety/Accident Prevention Program
5. National Fire Protection Association – NFPA 70E
6. ANSI Z244.1 American National Standards for Personnel Protection

- B. All tests shall be performed with apparatus de-energized except where otherwise specifically specified.
- C. The testing firm shall have a designated safety representative on the project to supervise operations with respect to safety.

3.04 EQUIPMENT TESTING REQUIREMENTS

- A. The intent of this specification is not to duplicate testing performed at the point of manufacture or to impose additional burden on the contractor which does not benefit the project. The intent is to verify that electrical equipment has been securely fastened down, supported, and installed in accordance with the manufacturer's requirements. The intent is also to verify that all electrical connections are correctly torqued, properly aligned, properly insulated, and properly supported and that equipment is clean and ready for operation.
- B. Except as noted below or as approved by engineer, test the following equipment and assemblies in full accordance with NETA-ATS 2003.
- C. Switchgear and Switchboard Assemblies
- D. Transformers, Dry Type, Air-Cooled, Low-Voltage, Small
- E. Cables, Low-Voltage, 600 Volt Maximum
 1. Perform tests only on cables size #4 AWG and larger.
- F. Switches, Air, Low-Voltage
 1. Perform tests only on switches rated 100 amps or higher.
- G. Switches, Cutouts
 1. Perform tests only on equipment rated 100 amps or higher.
- H. Circuit Breakers, Air, Insulated-Case, Molded-Case
 1. Perform visual and mechanical inspections in accordance with NETA for all circuit breakers.
 2. Perform electrical tests only on circuit breakers rated 100 amps or higher provided in power distribution and lighting/receptacle panelboards.
 3. No testing is required for circuit breakers provided as part of any of the following:
 - a. A UL listed control panel.
 - b. UL listed factory supplied motor control centers.
 - c. Stand-alone combination motor starters.

- I. Circuit Switchers
 - J. Network Protectors, 600 Volt Class
 - K. Protective Relays
 - L. Metering Devices
 - M. Regulating Apparatus, Voltage, Step and Induction Voltage Regulators
 - N. Grounding Systems
 - O. Ground-Fault Protection Systems, Low-Voltage
 - P. Rotating Machinery, AC Motors and Generators
 - 1. Motors provided as part of valve actuators do not require testing.
 - 2. Perform visual and mechanical inspections on all motors.
 - 3. Perform rotation tests on all motors.
 - 4. Perform electrical tests only on motors 50 horsepower and larger.
 - Q. Motor Control, Motor Starters, Low-Voltage
 - R. Adjustable Speed Drive Systems
 - S. Direct-Current Systems, Batteries, Flooded and Valve-Regulated Lead-Acid
 - T. Direct-Current Systems, Chargers
 - U. Surge Arresters, Low-Voltage Surge Protection Devices
 - V. Surge Arresters, Medium- and High-Voltage Surge Protection Devices
 - W. Capacitors and Reactors – All Types
 - X. Standby Power Systems, Engine Generator
 - Y. Standby Power Systems, UPS
 - Z. Standby Power Systems, Automatic Transfer Switches
 - AA. Fiber-Optic Cables
- 3.05 CONSTRUCTION
- A. Interface with Other Work
 - 1. Coordinate all testing activities with other disciplines. Retest any equipment disturbed or damaged in any manner after initial testing.

3.06 CLOSEOUT REPORT

- A. Provide comprehensive bound test report in accordance with Part 1 of this specification.

End of Section

SECTION 17000
INSTRUMENTATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes

1. Provide complete instrumentation and control systems as indicated on the Drawings, in the Specifications, and as required by other contract documents. These documents include descriptions of functional operation and performance, as well as standards, but do not necessarily enumerate detailed specifications for all components and devices which are necessary. However, all components and devices shall be furnished and installed as required to provide complete and operable systems for accomplishing the functions and meeting the performance requirements.
2. Scope of work includes:
 - a. Provide all instruments.
 - b. Provide all control panels, PLC panels, SCADA consoles.
 - c. Provide all communication equipment required to make the control system fully operational including but not limited to radios, antennas, switches, routers, hubs, protocol converters, communication cables, and communication racks and power supplies.
 - d. Provide all conduit, conductors, enclosures, materials, and labor to fully interconnect and make operational all control system components.
 - e. Provide power at proper voltage and ampacity to all system components.
 - f. Provide programming for the PLC and SCADA components.
 - g. Provide startup and commissioning assistance
 - h. Train Owner's personnel on proper use and maintenance of the control systems
 - i. Other equipment, materials, and work as necessary to achieve a fully tested and operational control system.

B. Products Supplied But Not Installed Under This Section

1. None

C. Products Installed But Not Supplied Under This Section

1. Instruments and controls provided loose for field installation by packaged equipment or skid-mounted equipment vendors.

D. Related Sections

1. All Division 16 specifications provided for this project.
2. All Division 17 specifications provided for this project.
3. Other division specifications provided for this project as they relate to submittals, concrete, structural, piping/plumbing, mechanical, and HVAC systems.

- E. Allowances
 - 1. Not applicable this section.
- F. Unit Prices
 - 1. Not applicable this section.
- G. Measurement Procedures
 - 1. Not applicable this section.
- H. Special Payment Procedures
 - 1. Not applicable this section.
- I. Alternates/Alternatives
 - 1. All alternates, alternatives, or proposed substitutions of materials or equipment must be approved by ENGINEER.

1.02 REFERENCES

1.03 DEFINITIONS

- A. The word "provide" means "furnish and install".
- B. PLC means Programmable Logic Controller
- C. SCADA means Supervisory Control and Data Acquisition System

1.04 SYSTEM DESCRIPTION

- A. Design Requirements
 - 1. Using sound engineering principals and current best design practices, provide engineering drawings and design documents specifying system components and detailing their interconnection and installation.
- B. Performance Requirements
 - 1. The instrumentation and control systems shall be furnished and installed complete and ready to operate, including all necessary interconnections and connections to sources of electrical power, air, water, drains and vents, with all required valves, switches and accessories as specified or as recommended for best operation by the manufacturer of the equipment furnished.

1.05 SUBMITTALS

- A. General
 - 1. Submittals for the equipment shall be provided in accordance with Section 16000, and as required elsewhere in the Contract Documents.
- B. Product Data
 - 1. Detailed catalog information for all system components in sufficient detail so that

ENGINEER has sufficient information to determine if the equipment is acceptable for the intended purpose. Minimum information shall be:

- a. Instrument or Equipment tag number
- b. Manufacturer
- c. Model number
- d. Materials of construction
- e. Materials in contact with process fluids
- f. Dimensional information
- g. Weight
- h. Power consumption with required voltage and ampacity
- i. Heat dissipation if greater than 200 watts
- j. Process connection information detailing connection size, type (threaded, flanged, socket weld, etc...)
- k. Recommended mounting details
- l. Recommended spare parts for one year of operation
2. Instrument Data Sheets in ISA S20 format for all instruments.

C. Shop Drawings

1. For complex control systems consisting of mechanical, electrical, and control components, provide the following:
 - a. A Piping and Instrument Diagram in ISA format
 - b. Electrical load calculations with conduit and conductor sizing
2. For integrated control panels or control assemblies, provide the following:
 - a. Dimensioned layout of the control enclosure and mounted equipment and instruments.
 - b. Full bill of material for all components with detailed catalog information on all components.
 - c. 11"x17" fully developed schematic diagram(s) showing power and control wiring, terminal block assignments, and identifying field and enclosure wiring. Provide a drawing index and symbols and legend sheet with all schematics. Show all I/O card details including rack, slot, channel numbers, field termination points, and control power wiring. Label all conductors and identify conductor size and color. Identify all field devices by tag number and by description. Provide over current protection in accordance with NEC requirements.
 - d. 11"x17" instrument loop drawings in ISA format for all analog control loops. Alternatively, multiple loops may be combined on a single analog input or analog output I/O card schematic diagram.
 - e. Nameplate legend
 - f. Paint color and type for painted assemblies
3. Any special installation details.

D. Samples

1. Not applicable for this section

E. Quality Assurance/Control Submittals

1. Design Data, Test Reports

- a. Submit calibration sheets for all field instruments containing the following information:
 - 1) Instrument tag number
 - 2) Instrument manufacturer and model number
 - 3) Person who performed the calibration
 - 4) Manufacturer, model and serial number of the calibrating device
 - 5) Date that calibrating device was last calibrated
 - 6) For analog instruments, process range and associated analog signal in at least 5 increments (For example: 4.00 maDC/0 psig, 8.00 maDC/25 psig, 12.00 maDC/50 psig, 16.00 maDC/75 psig, 20.00 maDC/100 psig)
 - 7) For switches, process values at which the switch changes state and at which the switch resets.
 - 8) For instruments calibrated by manufacturer, manufacturer's calibration report is acceptable as proof of calibration.
- b. Factory acceptance test reports on all fabricated control panels or assemblies containing the following information:
 - 1) Date of test
 - 2) Test participants
 - 3) Visual inspection of components
 - 4) Successful application of power
 - 5) Validation of all internal wiring
 - 6) Validation of correct control operation
 - 7) Validation of screen graphics or alarm operation (if applicable)
 - 8) Validation of program installation into PLC's and that I/O is functioning properly (if applicable)
- 2. Certificates, Manufacturer's
 - a. UL 508 certification for all assembled control panels and assemblies
- 3. Instructions, Manufacturer's Field
 - a. Furnish a complete Operations and Maintenance Manual for all assembled control panels and assemblies
- 4. Reports
 - a. Not applicable to this section

F. Closeout Submittals

- 1. Furnish Operations and Maintenance Manuals in 3-ring binders complete with the following:
 - a. On front and spine of binders provide the project name, owners name and project number.
 - b. Within the binder, identify the contractor and provide contact information
 - c. Inside binders, provide a volume index and table of contents for each binder. Each instrument or control component tag number must be cross referenced to a specific binder tab.
 - d. Furnish manufacturers complete operations and maintenance manuals for all discrete instruments and controls.
 - e. Furnish custom Operations and Maintenance section for each custom control system, control panel, or fabricated assembly.
 - f. Furnish "As-Built" loop and wiring diagrams.

- g. Furnish the written warranty
- 2. Turn over all spare parts to owner with documentation showing which instrument or control system the spare parts are for.

G. Schedule

- 1. Submit a detailed work schedule showing start/finish dates, task duration, task sequencing, critical path, and available float. Identify task predecessors and identify coordination activities with other trades.

H. Startup and Commissioning Plan

- 1. Submit a detailed startup and commissioning plan for review by Owner and Engineer. Plan should include the following information:
 - a. The order in which the various plant systems will be started up
 - b. What work must be performed prior to the startup
 - c. What documentation will be maintained by the contractor and provided to the owner validating that the startup was performed in a safe and efficient manner.

1.06 QUALITY ASSURANCE

A. Qualifications

- 1. Contractor performing the work shall have a minimum 5 years experience performing similar work in similar industries. All contractors' personnel shall be trained and experienced in best current construction practices.

B. Regulatory Requirements

- 1. Perform all work in accordance with all applicable national and local codes.

C. Certifications

- 1. Not applicable this section

D. Field Samples

- 1. Not applicable this section

E. Mock-Ups

- 1. Not applicable this section

F. Pre-Installation Meetings

- 1. Not applicable this section

1.07 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading

- 1. Perform these activities in a manner which assures instruments and equipment will arrive undamaged and in proper working order. Replace any instrument or equipment damaged upon arrival at no additional cost to owner.

B. Acceptance at Site

1. Maintain a comprehensive log by instrument or equipment tag number of all received instruments or equipment

C. Storage and Protection

1. Store all instruments and equipment as recommended by manufacturer. Protect from physical damage, moisture, dirt/dust, or extremes of temperature

1.08 PROJECT/SITE CONDITIONS

A. Environmental Requirements

1. Follow any and all environmental requirements pertaining to the site
2. Maintain a safe and clean job site
3. Dispose of all trash and construction debris in an approved manner

B. Existing Conditions

1. Contractor is to examine the site and be thoroughly familiar with any site requirements which may affect the work or storage of instruments or equipment.

1.09 SEQUENCING

- A. Coordinate all work with other trades.

1.10 SCHEDULING

- A. Provide and maintain a detailed schedule for performance of the work identifying start/finish dates, durations, required preceding activities, and coordination with other trades. Organize procurement, deliveries, and staff labor to meet the overall construction schedule and to assure that other trades are not delayed.

1.11 WARRANTY

A. Instrumentation

1. One year from system acceptance by owner for all discrete instrumentation, control devices, or equipment. During this period, replace any defective or malfunctioning device with 15 working days after notification by owner.
2. One year from system acceptance by owner for the performance of the overall control system. Correct the defect within 15 working days after notification by owner. Warranty repair work includes but is not limited to the following:
 - a. Improper sequencing or interlocking of equipment control systems
 - b. Wiring errors or omissions
 - c. Improper calibration of field instruments
 - d. Improper operation of programmable logic controllers or operator interface terminals
 - e. Improper operation of communications systems installed as part of the overall control system
 - f. Unsafe operations or maintenance conditions
 - g. Other system malfunctions which prevent or impair the plant from operating at design capacity, requires excessive operator intervention, or results in

unsafe operating conditions.

1.12 SYSTEM STARTUP/COMMISSIONING

A. General

1. Provide labor, tools, and equipment to start up the facility in a safe and efficient manner.
2. Plant shall be started up by system. A system is defined as a collection of mechanical, electrical, and controls equipment configured to perform a specific function or purpose. Examples may be a UV disinfection system, a dissolved oxygen blower system, a grit removal system, etc... The order in which the systems will be started shall be submitted by contractor in the startup plan and approved by owner and engineer. Any variance in this schedule must be approved by owner and engineer.
3. Unless approved otherwise by owner and engineer, contractor is to follow the startup sequence detailed below. The following work must be complete prior to beginning the startup:
 - a. All mechanical equipment installed and tested in accordance with manufacturers recommendations.
 - b. All motors must have been rotation checked.
 - c. Electrical power is available and wired to all mechanical equipment
 - d. All instruments must have been calibrated and installed in accordance with the manufacturer's recommendations.
 - e. Control system communication systems are installed and fully operational. This includes DH+ networks, Modbus+ networks, Ethernet networks, radio telemetry systems, telephone systems, etc...
 - f. All power and control wiring must be installed, rung out, and validated to be in accordance with approved construction drawings.
 - g. Programmable logic controllers, SCADA computers, and Operator Interface Terminals all are installed, have their programs installed, and these devices are fully operational and functioning in their design configuration.

B. System Startup Sequence

1. By manipulation of the instrument or direct signal injection at the instrument, verify that the control signal (discrete or analog) is received at the programmable logic controller or by the hard wired control circuit.
2. For motorized equipment, disconnect the power leads at the starter, VFD, or solid state motor controller.
3. Completely exercise the control circuit in Manual, Remote, and Automatic modes and verify that all interlocks and permissives are functioning correctly.
4. Verify that the programmable logic controller can start and stop the motor in Auto or Remote. Motors may be "bumped" by forcing PLC outputs but these program forces must be removed immediately afterward.
5. Verify that run status, signal levels, and alarms display properly on the OIT and the SCADA screens.
6. Reconnect the motor power leads.
7. Verify PID loop operating correctly (either direct or reverse) and adjust gain

constants to achieve critically damped operation.

8. Configure the mechanical system for normal operation and leave system ready for normal operation.
9. Utilize colored tagging scheme to identify startup condition. Red is not ready for startup, yellow is mechanically and electrically ready but not yet tested or started up, and green is fully tested and ready for normal operation. Place these tags on all mechanical, electrical, instrumentation, and control components of each system.
10. As plant systems are started up, coordinate and remedy any coordination or interface issues between systems.

C. Remedies for Damages

1. Contractor is liable for any and all damage done to mechanical or electrical equipment due to improper startup procedures and shall repair or replace any damaged equipment at owner's discretion without additional cost to owner.
2. Contractor is forbidden to jumper around any process or safety interlock either with wiring or within a PLC program without the express written permission of both the owner and engineer. All jumpers, hardwired and programmed, must be maintained in a log book. Entries shall include:
 - a. Name of person placing the jumper
 - b. Date of installation
 - c. Reason for installation
 - d. Approval of owner and engineer
 - e. Date of removal
 - f. Name of person removing the jumper

1.13 OWNER'S INSTRUCTIONS

- A. Not applicable this section

1.14 MAINTENANCE

A. Extra Materials

1. Not required this section

B. Maintenance Service

1. Not required this section

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Approved manufacturers are listed in the other Electrical and Instrument Specification Sections.

2.02 EXISTING PRODUCTS

- A. Not applicable this section

2.03 MATERIALS

- A. All materials are to be new and the manufacturers most current model.

2.04 MANUFACTURED UNITS

- A. Manufactured units are to be fully assembled and tested at the point of manufacture and delivered to the job site ready for installation and start-up.
- B. Regulated dc power supplies for instrument loops shall be designed and arranged so that loss of one supply does not affect more than one instrument loop or system. Power supplies shall be suitable for an input voltage variation of plus or minus 10 percent, and the supply output shall be fused or short circuit protected. Output voltage regulation shall be as required by the instrumentation equipment being supplied. Multi-loop, or multi-system power supplies, will be acceptable if backup power supply units are provided which will automatically supply the load upon failure of the primary supply. The backup supply systems shall be designed so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the instrument system operation.
- C. The power distribution from multi-loop supplies shall be selectively fused such that a fault in one instrument loop will be isolated from the other loops being fed from the same supply. Fuses shall be clearly labeled and located for easy access. Multi-loop supply systems shall be oversized for an additional 10 percent future load. Failure of a multi-loop supply shall be indicated on the respective instrument panel or enclosure.

2.05 EQUIPMENT

- A. All equipment is to be new and the manufacturers most current model. All instruments and control devices and assemblies shall be standard devices constructed of corrosion-resistant materials enclosed in a water and dust proof case and mounted as specified in the individual application. Enclosures shall be manufacturer's standard color unless specified otherwise.

2.06 COMPONENTS

- A. Not applicable this section

2.07 ACCESSORIES

- A. Not applicable this section

2.08 MIXES

- A. Not applicable this section

2.09 FABRICATION

A. Shop Assembly

1. Fabricate assemblies in accordance with approved drawings. Notify engineer and owner at least 5 working days prior to start of testing so that they may witness the testing if they choose to do so.

2.10 FINISHES

A. General

1. Finishes for all components, equipment, and fabricated assemblies must take into account the environment in which they will be installed. NEMA ratings must be appropriate for the environment. Ratings for corrosive areas must be NEMA 4X, for outdoor areas NEMA 4 or 3R, indoor dusty areas may be NEMA 12.

B. Shop Finishing

1. Where called for in other sections, sandblast, prime, and paint assemblies.

2.11 SOURCE QUALITY CONTROL

A. Fabrication/Tolerances

1. In accordance with generally accepted manufacturing standards

B. Tests, Inspections

1. In accordance with generally accepted manufacturing standards

C. Verification of Performance

1. Not applicable this section

PART 3 - EXECUTION

3.01 ACCEPTABLE INSTALLERS

- A. Contractors having a minimum 5 years experience in the design, procurement, and construction of industrial water/wastewater instrumentation and control systems.

3.02 EXAMINATION

A. Site Verification of Conditions

1. Visit job site and ascertain any environmental or physical conditions which may affect the performance of the work or the equipment requirements

3.03 PREPARATION

A. Protection

1. Not applicable this section

B. Surface Preparation

1. Not applicable this section

3.04 ERECTION

- A. Provide 4 inch tall reinforced concrete housekeeping pads for all control panels and floor mounted fabricated control assemblies and consoles. Dowel into concrete base and extend a minimum of 2" past edges of equipment.
- B. Provide unistrut or fabricated structural supports for heavy equipment or assemblies. Prime and paint supports so that they are unaffected by the environment in which they are installed.
- C. Securely fasten all panels and assemblies to their housekeeping pads or structural supports.
- D. All interconnecting wiring shall be run in conduit in accordance with the division 16 sections requirements.

3.05 INSTALLATION

- A. Install all instruments and controls in accordance with manufacturer's recommendations and all applicable electrical codes and standards. Connect all required utilities including electrical power, air, hydraulics, etc...
- B. Provide stainless steel tags for each instrument engraved with instrument tag number. Attach to instrument with stainless steel wire.
- C. Provide engraved nameplates for all panel mounted instruments. Attach to panel with stainless steel screws.

3.06 APPLICATION

- A. Not applicable this section

3.07 CONSTRUCTION

- A. Special Techniques
 - 1. In accordance with manufacturers recommended installation procedure
- B. Interface with Other Work
 - 1. Coordinate with all other trades
- C. Sequences of Operation
 - 1. Not applicable this section
- D. Site Tolerances
 - 1. Not applicable this section

3.08 REPAIR/RESTORATION

- A. Repair any damages caused by the installation or erection to original condition.

3.09 RE-INSTALLATION

- A. Not applicable this section.

3.10 FIELD QUALITY CONTROL

- A. Site Tests
 - 1. Test and calibrate instrumentation in accordance with other parts of this section
- B. Inspection
 - 1. Not required this section
- C. Manufacturer's Field Services
 - 1. If recommended by manufacturer, have equipment/control systems inspected, tested, and started up by manufacturer's representative.

3.11 ADJUSTING

- A. Not required this section

3.12 CLEANING

- A. Remove and dispose of construction debris daily. Wipe down and vacuum out all enclosures.

3.13 DEMONSTRATION/TRAINING

- A. In accordance with the Startup part of this section.
- B. Provide training of personnel in the operation and maintenance of the furnished control systems.
- C. Training shall be provided as required elsewhere in the Contract Documents, but shall consist of at least eight hours, in a single, or multiple sessions, to accommodate the personnel schedules.
- D. Coordinate with the Engineer, and the Owner, to schedule the training sessions at least 5 workdays in advance.

3.14 PROTECTION

- A. Protect instrumentation and control equipment from environmental damage and from damage by other trades.

3.15 SCHEDULES

- A. Not applicable this section.

End of Section

SECTION 17121

PRESSURE SWITCHES

PART 1 GENERAL

1.01 SCOPE

- A. This section covers Pressure Switches and Differential Pressure Switches as shown on the Drawings.
- B. Related work specified elsewhere includes, but is not limited to Section 16000, electrical. Also refer to requirements of General Conditions for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for and guarantee performance of the equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the equipment.
- B. Reference standards shall be the latest edition, including addenda, supplements, and revision. Applicable reference publications include the following:

NEC
NEMA

1.03 SUBMITTALS

- A. Submit product information cut sheets containing manufacturer's specifications, Operations and Maintenance data, instrument enclosure type, installation location, and process pressure range to be supplied. Indicate product part number in full.
- B. Provide submittals in accordance with Section 16000, and elsewhere in the Contract Documents.

PART 2 PRODUCTS

2.01 PRESSURE SWITCHES

- A. Pressure switches shall be capable of dual control with independent set points and adjustable deadbands. Differential pressure switches shall be capable of single control with adjustable set points and adjustable deadband. Switches shall be snap action, single-pole, double-throw switching elements with an electrical rating of at least 10

amperes at 120 VAC. Pressure switches shall be enclosed in a NEMA 4 or weatherproof housing.

- B. Operating pressures and set points shall be determined in the field, unless otherwise indicated on the Drawings.
- C. Set points shall be fully adjustable and shall be in the middle of the working range. Set point adjustments shall be made with adjustment screws or thumbwheels. Accuracy shall be plus or minus one percent of adjustable range.
- D. For pressures up to 150 PSIG pressure sensing element shall be of the diaphragm or bourdon tube type, and shall have a proof pressure of at least twice the maximum working pressure. For pressures above 150 PSIG, sensing element shall be bourdon tube type. Diaphragms or bourdon tubes shall be stainless steel.
- E. Pressure switches shall be installed with individual ball valves for isolation. Valve material shall be compatible with the process piping and process fluid. In addition, process piping up to the sensor shall be insulated to protect against freezing.
- F. Pressure switches shall be as manufactured by Barksdale Controls Series D2H, Mercoid Controls Series DAW, or equal.
- G. Differential pressure switches shall be as manufactured by Barksdale Controls Series DPD1T, Mercoid Controls Series DPAW, Ashcroft Instruments GDA-Series, or equal.
- H. Diaphragm seals shall be manufactured by Ashcroft, or equal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified and shown on the drawings. Contractor shall coordinate with Mechanical and Piping to insure proper connection to piping and/or other mechanical equipment.

3.02 ACCEPTANCE

- A. As a condition precedent to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

End of Section

SECTION 17124

SUBMERSIBLE LEVEL TRANSMITTER

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the Submersible Level Transmitters to be provided where indicated on the Drawings.
- B. Related work specified elsewhere includes, but is not limited to section 16000 Electrical. Also, refer to requirements of General Conditions for testing, adjusting and balancing of systems.

1.02 QUALITY

- A. Equipment to be furnished under this section shall be the products of companies regularly engaged in the design and manufacture of this type of equipment. Manufacturers shall assume responsibility for, and guarantee performance of, equipment furnished. However, this shall not be construed as relieving the Contractor from their responsibility for the proper installation and functioning of the equipment.
- B. Reference standards. Standards shall be the latest edition, including addenda, supplements, and revision. Applicable reference publications include the following:

NEC
NEMA

1.03 SUBMITTALS

- A. Submit product information cut sheets containing manufacturer's specifications, Operations and Maintenance data, instrument enclosure type, installation location, and process pressure range to be supplied. Indicate product part number in full.
- B. Provide submittals in accordance with Section 16000, and elsewhere in the Contract Documents.

PART 2 - PRODUCTS

2.01 SUBMERSIBLE LEVEL TRANSMITTER

- A. The submersible level transmitter system shall be designed for total submersion, and shall have the following features:
 - 1. Accuracy of +/-0.1% of full scale.
 - 2. Titanium construction.
 - 3. Two-wire, 4 mA output at zero pressure, 20 mA output at full range pressure.

4. Operating pressure ranges from 1 psi to 900 psi, as required by the application.
5. Overpressure rating shall be 4 times the operating pressure range from 1 to 5 psi, and 2 times the range for 10 psi and above.
6. Pressure transducer shall be of the integrated silicon strain gauge bridge type.
7. Transmitter supply voltage shall be 9-30 VDC.
8. Operating temperature shall be -20 to +60 degrees C.
9. Transmitter shall be provided with sufficient cable length to reach terminations point shown on the Drawings.

- B. Submersible level transmitter shall be Druck Inc., model PTX 1830, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified, and as shown on the Drawings. The Contractor shall coordinate the installation with the other trades, to insure proper installation of the transmitter, and associated conduit and cables.
- B. The instrument shall be factory calibrated to the proper ranges, as required by the Owner and the Engineer. Where analog signals are connected to local, or remote monitoring equipment, the Contractor shall verify that the calibrated ranges and scaling of the local and remote indicators are correct.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

End of Section

SECTION 17137

MAGNETIC FLOWMETERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the Magnetic Flowmeters to be provided where indicated on the Drawings. The flowmeters shall consist of two parts with manufacturer supplied interconnecting wiring, the field installed flow element and the flow indicating transmitter.
- B. Related work specified elsewhere includes, but is not limited to section 16000 Electrical. Also, refer to requirements of Contract Documents for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer prior to installation, in accordance with Section 16000, and as required elsewhere in the Contract Documents:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

PART 2 - PRODUCTS

2.01 MAGNETIC FLOWMETERS:

- A. Acceptable Manufacturers:
 - 1. Bailey-Fisher & Porter, Series 3000, MAG-X with Series M2 Converter.
 - 2. Sparling model FM657 TigerMag.
 - 3. Krohne Altoflux IFS 4000F primary head (flow element) with a remote mount IFC 020 F signal converter (transmitter).
 - 4. Or Equal.

B. Materials:

1. All mounting hardware shall be 316 stainless steel, the instrument enclosure shall be rated NEMA 4X, the flow sensor liner shall be Polyurethane lined, and the electrode material shall be 316 stainless steel.

C. Design and fabrication

1. Utilize characterized field principle of electromagnetic induction to produce signal directly proportional to flow rate.
2. Provide flanged end connections per ANSI B16 rated for piping system operating and test conditions.
3. Operating pressure: 100 psi.
4. Operating temperature: 122 DegF.
5. Grounding requirements:
 - a. Nonmetallic or lined pipe:
 - 1) Inlet and outlet grounding rings of same material as electrode.
 - b. Conductive piping:
 - 1) Conductive path between the meter and the piping flanges.
6. Provide cable between magnetic flowmeter and transmitter.
7. Pulsed DC magnetic field excitation.
8. Automatic zero
9. Adjustable low flow cutoff.
10. 16-character alphanumeric display shall indicate user-defined flow units and total flow. All menu advice and commands shall be viewed on this display.
11. Minimum signal lock (empty tube zero) to prevent false measurement when tube is empty.
12. Accuracy:
 - a. +/- 0.5 percent of rate above 1 fps.
 - b. +/- 0.01 fps below 1.0 fps.
 - c. 4-20 mA DC isolated output into maximum 800 ohms.
 - d. Scaled frequency output, 24 VDC.
 - e. Power supply: 117 V +/- 10 percent, 60 HZ.
 - f. Meter operable as specified in liquids with 5.0 micromho/cm or more conductivity.
13. Electrodes shall be self-cleaning.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified, and as shown on the Drawings. The Contractor shall coordinate the installation with the other trades, to insure proper installation of the flow element, transmitter, and associated conduit and cables.
- B. The Contractor shall calibrate the instruments to the proper ranges, as required by the Owner and the Engineer. Where analog signals are connected to local, or remote

monitoring equipment, the Contractor shall verify that the calibrated ranges and scaling of the local and remote indicators are correct.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

3.03 SPARE PARTS

- A. Provide the Owner with a list of the manufacturers' recommended spare parts.

End of Section

SECTION 17150

LIMIT AND POSITION SWITCHES

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes
 - 1. Position and proximity switches used to monitor equipment status and to detect security intrusion.
- B. Related Sections
 - 1. Other Division 16000 sections
 - 2. General Conditions for testing, adjusting and balancing of systems.

1.02 SYSTEM DESCRIPTION

1.03 SUBMITTALS

- A. In accordance with Section 16000, and elsewhere in the Contract Documents.
- B. Product Data
 - 1. Product information brochures, catalog cut sheets, other product literature containing manufacturers specifications, sizes, ratings, enclosure type and details, conditions-of-use, and fully developed part numbers.
- C. Reference standards shall be the latest edition, including addenda, supplements, and revision. Applicable reference publications include the following:

NEC
NEMA

- D. Quality Assurance/Control
 - 1. Manufacturers instructions for use.

1.04 QUALITY ASSURANCE

- A. Manufacturer must be regularly engaged in the design and manufacture of this type of equipment and shall assume responsibility for and guarantee performance of the equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the equipment.

PART 2 PRODUCTS

2.01 MANUFACTURES

- 1. Cutler Hammer

2. Square D

2.02 GENERAL

- A. Heavy duty, industrial grade units with NEMA rated housings compatible with installation location and environmental conditions. Enclosures to be NEMA 4X unless noted otherwise or provided as part of a packaged system.
- B. Electrical contact sets configured as shown on drawings and rated for 5 amps at 250 volts minimum.
- C. Sensing elements must have provisions for field mechanical adjustment.

2.03 LIMIT SWITCHES - MECHANICAL

- A. Combination switch housing and position sensing lever coordinated with mechanical equipment whose position is to be sensed. Lever sensing arm to be rated for 10,000 mechanical operations.

2.04 LIMIT SWITCHES - PROXIMITY

- A. Integrated capacitive or inductive proximity sensing unit and switch housing. Coordinate sensing distance with mechanical equipment whose position is being sensed. Provide with adjustable mounting bracket compatible with the switch housing and environmental conditions.

2.05 LIMIT SWITCHES – PHOTO-ELECTRIC

- A. Combination switch housing with photo-electric sensor and separate photo-electric emitter or photo-electric reflective unit. Coordinate sensor style, beam intensity, and wavelength with mechanical equipment whose position is being sensed. Unit must operate reliably under all ambient light conditions. Power supply and contact ratings as shown on drawings.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install and connect as specified and shown on the drawings.
- B. Adjust position sensing elements for reliable and repeatable operation.
- C. Coordinate with Mechanical and other trades to insure proper connection to mechanical or other equipment.

3.02 ACCEPTANCE

- A. Certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications. This requirement is in addition to the manufacturer's guarantee.

End of Section

SECTION 17222

SIGNAL CONDITIONERS

PART 1 - GENERAL

1.01 SCOPE

- A. This section contains specifications for analog (4-20 mA DC) signal conditions, used for loop isolation, protection, and switching. Refer to the Drawings and provide the devices as indicated.
- B. Related work specified elsewhere includes, but is not limited to section 16000, Electrical. Also refer to requirements of General Conditions for testing, adjusting and balancing of systems.

1.02 QUALITY ASSURANCE

- A. Equipment to be furnished under this section shall be the product of firms regularly engaged in the design and manufacture of this type of equipment. Manufacturer shall assume responsibility for, and guarantee performance of equipment furnished. However, this shall not be construed as relieving the Contractor from responsibility for the proper installation and functioning of the work.

1.03 SUBMITTALS

- A. The following material shall be submitted to the Engineer prior to installation, in accordance with Section 16000, and as required elsewhere in the Contract Documents:
 - 1. Where applicable, provide complete manufacturer's part number, identifying scaling, operating range, housing and wetted parts materials, NEMA rating, product options, consumable materials, and other pertinent information.
 - 2. Prior to Final Acceptance of the work, the Contractor shall provide Operations and Maintenance Manuals, in accordance with the Contract Documents.

1.04 MANUFACTURERS

- A. Moore Industries
- B. Phoenix Contact
- C. Measurement Technologies Ltd.
- D. Action Instruments, Inc.
- E. Approved equal.

PART 2 - PRODUCTS

2.01 CURRENT-TO-CURRENT CONVERTER

- A. Current-to-current converters shall provide electrical isolation between the input and output. Current-to-current converters shall be supplied where indicated on the Drawings, and wherever the circuit impedance exceeds the capability of a transmitter.
- B. The converter shall receive a 4-20 mA DC analog current input signal and produce an identical 4-20 mA DC output signal into a 0-1000 ohm load. Accuracy shall be ± 0.1 percent of span. The converter shall be provided with an enclosure suitable for back of panel mounting.
- C. Power requirements shall be 120 VAC, or 24 VDC, as indicated on the Drawings.

2.02 DUAL CHANNEL CURRENT ISOLATOR

- A. Dual channel current isolators shall provide electrical isolation between the input and output. The instruments shall receive a 4-20 mA DC analog current input signal and produce two identical 4-20 mA DC output signals.
- B. Each channel shall be fully isolated, and capable of driving a 0-650 ohm load. Accuracy shall be ± 0.1 percent of span. The isolators shall be provided with an enclosure suitable for back of panel mounting.
- C. Power requirements shall be 120 VAC, or 24 VDC, as indicated on the Drawings.

2.03 SET POINT RELAY

- A. The set point relays shall be solid state devices, and shall provide dual output relay contact closures from a 4-20 mA DC input. Each relay shall be controlled by an adjustable set point from a 10-turn potentiometer.
- B. The dual deadbands shall be adjustable from 0 to 100 percent. The output relay shall be DPDT with contacts rated 10 amps at 120 VAC. Accuracy and repeatability shall be within 0.1 percent of span.
- C. The instruments shall be immune to humidity and line voltage regulation problems. Power requirements shall be 120 VAC, or 24 VDC. The unit shall be housed in a general purpose type housing suitable for subpanel mounting in a control panel enclosure.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment and materials specified in this section shall be installed and connected as specified, and as shown on the Drawings.

3.02 ACCEPTANCE

- A. Prior to final acceptance of the work, the Contractor shall certify the equipment and installation included under this section to be free of defects, and suitable for trouble-free operation under the conditions set forth in these specifications.

3.03 WARRANTY

- A. The equipment listed in this section shall have a seven year warranty from the manufacturer.

End of Section